

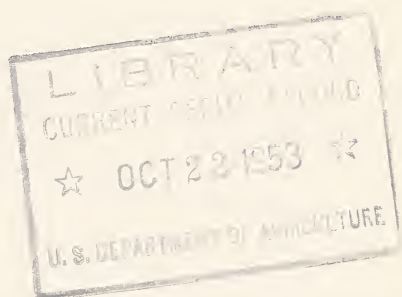
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Cleaning Cotton at Gins and Methods for Improvement



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Cleaning Cotton at Gins and Methods for Improvement

By VERNON P. MOORE, *cotton technologist, Cotton Branch, Production and Marketing Administration*, and CHARLES M. MERKEL, *agricultural engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

GIN CLEANING EQUIPMENT, DEVELOPMENT, AND USE

The practice of cleaning cotton at the gin has developed gradually through the years to meet the demands that have arisen as a result of rougher harvesting methods. During the early days of the cotton gin, no effort was made to clean cotton before it was ginned. Careful, clean, hand-harvesting practices were the rule. The harvesting was done by workers on the farm, most of whom had a direct interest in the crop. The seed cotton was placed in storage, and ginning, which in most cases was one of the farm operations, was started after harvesting had been completed. There was very little need for cleaning equipment when clean hand-harvesting practices were followed. Gradually, improvements were made in gin machinery, and mechanical and pneumatic cotton-handling systems were devised; however, because many farmers could not afford to buy gins for use on their farms, the commercial gin came into existence.

The development of multiple-row planters, cultivators, tractors, and other labor-saving equipment enabled the farmer and his tenants to produce more cotton than could be harvested without utilizing additional off-the-farm labor. In their efforts to pick as much cotton as possible in a day, this transient labor resorted to rougher harvesting methods than had been the custom. Such rough-harvesting practices created a need for seed cotton cleaning equipment that would remove foreign matter from the seed cotton before ginning and preserve the quality of the ginned lint.

The several types of cleaners that made their appearance on the market during the early 1900's included various types of extractors and beater or spiked-drum cleaners. The cotton received very harsh treatment in these machines and for this reason they were not recommended for use on the long-staple cottons grown in the Mississippi Valley States. It was found, however, that they could be used rather successfully on the short-staple varieties grown in the western areas of the Cotton Belt. The cleaners were used to extract the foreign matter from roughly harvested cottons in that area.

As these rough-harvesting practices spread gradually throughout much of the Cotton Belt, gin manufacturers and others continued their efforts to improve existing machinery and to devise new types of cleaners to preserve the quality of ginned lint. Even after these cleaners had been much improved, it was found that it was still impractical to use them on cotton that was damp or relatively long in staple.

Patents covering both the drying process and method of drying were obtained by the U. S. Department of Agriculture in 1928, and in 1931 the U. S. Cotton Ginning Laboratory at Stoneville, Miss., successfully demonstrated the practicability of a seed cotton drier for use at gins (fig. 1). This drier opened a new field in cleaning at the gin, since dry cottons can be cleaned much more readily than damp cottons; and cottons dried with the drier may be subjected, without adverse effect on fiber quality, to a greater amount of seed cotton cleaning by machinery than undried cotton.

Equipment for cleaning seed cotton consists of conventional type spiked-drum, spider-arm, paddle-wheel or toothed cylinders operating over some type of screen, concave bar grid, or other cleaning medium, and saw-cylinder cleaners and extractors, or combinations of these various types. With a few exceptions, the principles followed in the construction of these machines have remained virtually unchanged; however, the development of effective drying facilities has made it possible to subject cotton to more cylinders of cleaning without adverse effects.

The types and amount of cleaning machinery used vary widely throughout the Cotton Belt and are closely related to the kinds of cotton grown and the harvesting methods used. Before 1900, very few gins used seed cotton cleaning equipment. The cleaner equipment represented not more than 5 percent of the total machinery investment in gins in which it was included. By the time the cotton drier came into general use in 1935, the seed cotton cleaning and drying equipment represented about one-third of the total machinery costs of a gin. The amount of cleaning equipment has increased rapidly since that time, and in 1950 the cleaning and drying equipment represented about one-half of the machinery investment in a gin designed for handling rough-harvested cottons.

As a result of half a century of progress in the development of gin machinery, a gin plant equipped to handle rough-harvested cottons now has provision for the seed cotton to enter the gin through a 10- to 12-inch suction pipe and be dropped through a separator into a hot-air line where it is conveyed through a drying unit by heated air for the purpose of reducing the moisture content. This conditioning treatment facilitates trash removal by the subsequent cleaning processes and reduces the danger of fiber damage which would result from cleaning and ginning the damp cotton. In areas where the cotton contains sand and unopened bolls in noticeable quantities, air-line cleaners fitted usually with 4 to 6 or more cleaning cylinders are employed in the suction line ahead of the separator. The function of this cleaner is to remove large quantities of sand and some sticks and stems from the cotton, and to open the bolls. This process also serves to increase the efficiency of subsequent extracting processes.

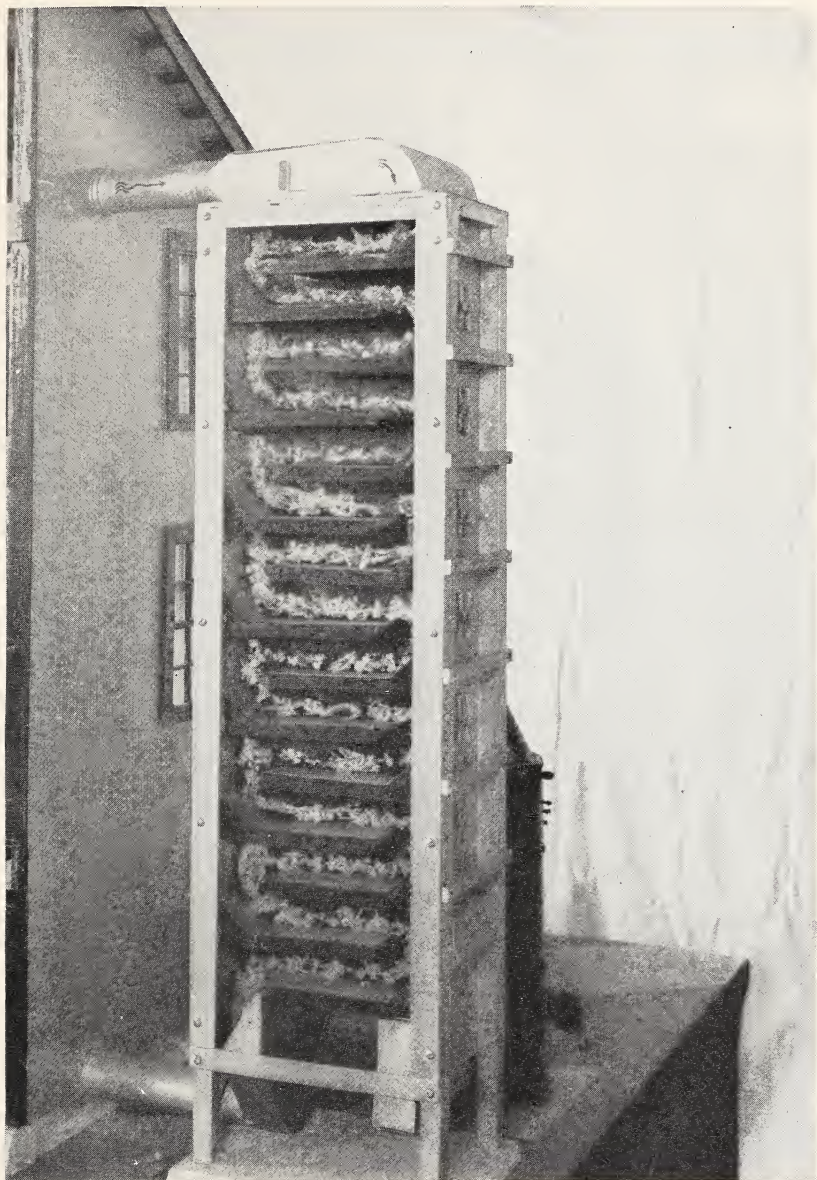


FIGURE 1.—Cross sectional view of a tower drier.

After the cotton has passed through the drier, it goes to cylinder cleaners for opening and cleaning. The conventional cylinder cleaner is equipped with a spiked-drum or spider type of cylinder which carries and "scrubs" the seed cotton over wire mesh or perforated metal screens through which fine particles of leaf trash, dirt or sand, stems, and small sticks are expelled from the cotton (fig. 2). In some

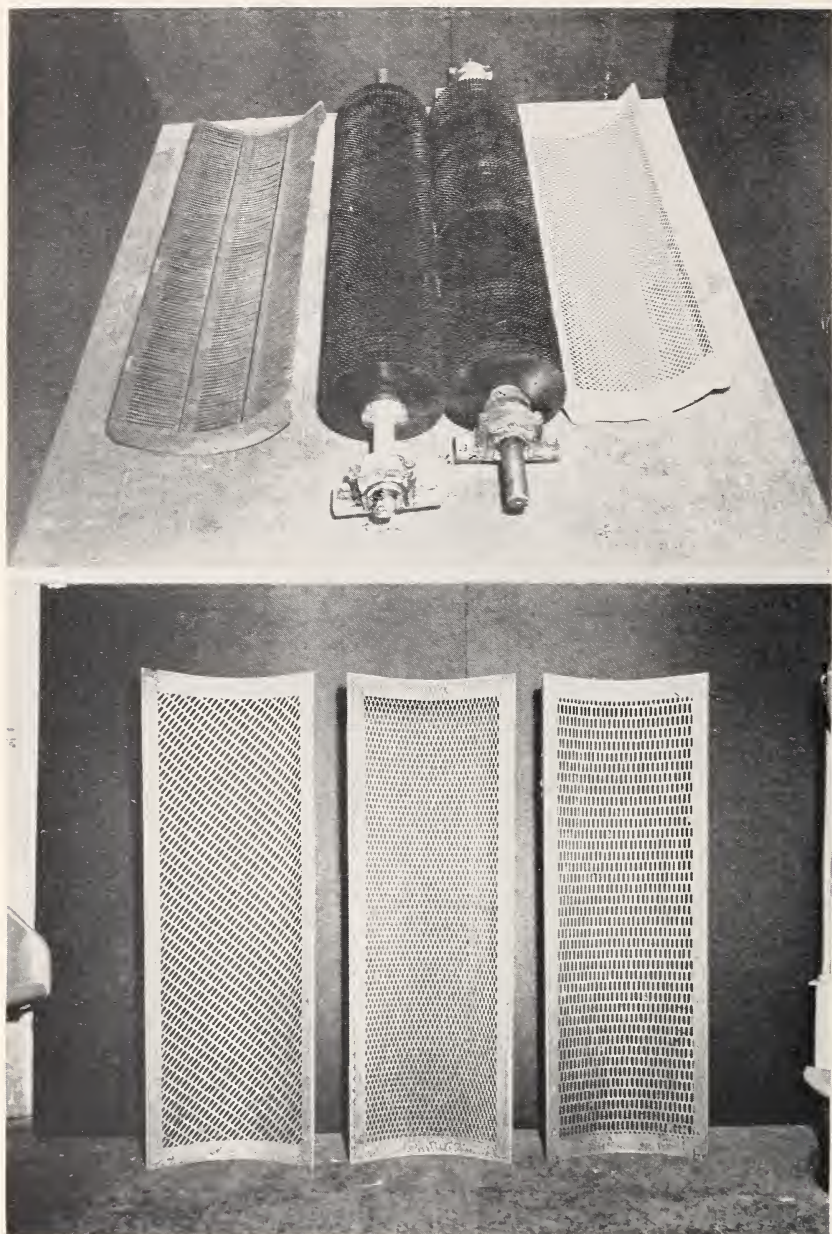


FIGURE 2.—Various types of screens used in cylinder cleaners. Left to right, top row: Bar grid, knuckle-tooth disc revolving screen, hardware cloth. Bottom row: Diagonal pattern perforated metal, expanded metal, rectangular slot perforated metal.

installations the suction of a trash-disposal fan connected with the trash hopper draws the dislodged trash away from the cotton, thereby increasing the effectiveness of the cylinder cleaner. The number of cylinders in such a cleaner ranges from 5 to 15 (fig. 3). As the cotton leaves this cleaner, it is conveyed to the bur-extracting machinery, the function of which is to remove burs, sticks, and stems, as well as more of the fine particles of trash such as those removed by cylinder cleaners.

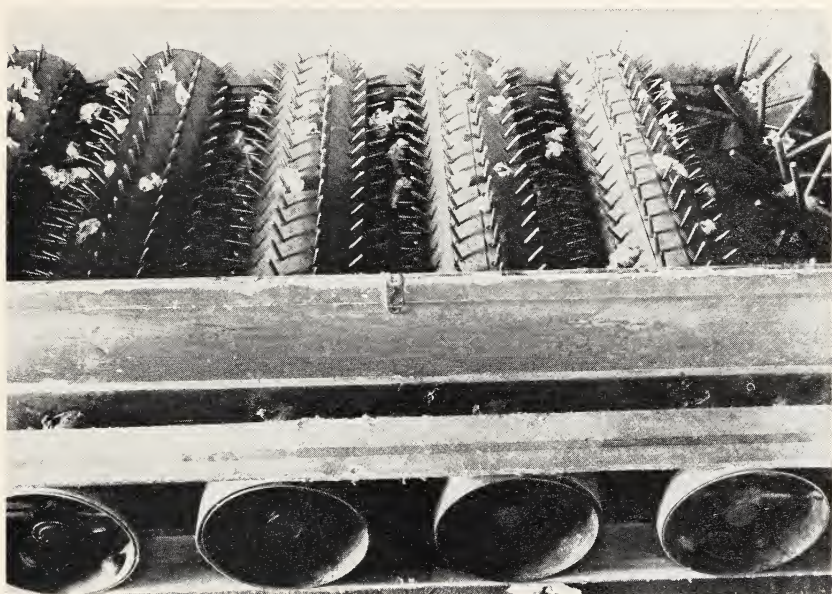


FIGURE 3.—Interior view of a cylinder cleaner.

Normally, a 3- or 4-stand gin is equipped with a 10- to 14-foot bur machine; a 5- to 6-stand gin often requires two bur machines or their equivalent (fig. 4). These machines employ a revolving saw cylinder which is about 30 inches in diameter. The teeth of the saw hold the locks of seed cotton, subject them to a carding and cleaning action as the cotton is spread across the surface of the saw cylinder, and strip them of heavy trash and burs. Spiked-drum cleaning cylinders are also included in these machines to direct the flow of cotton and to supplement the cleaning action of the saw cylinder. Although each piece of cleaning equipment has its proper place in the sequence of cleaning seed cotton, the bur machine or its equivalent is one of the most valuable when handling rough-harvested cotton because it performs an extracting and cleaning action whereas cleaners do cleaning only and no extracting.

After the bur-extracting process, the seed cotton is discharged into cylinder cleaners for a further cleaning action. At this point, the cotton may be passed to a second drier for further conditioning en route from the bur machine to finishing cleaners. The cleaning units at this stage may consist of from 6 to 15 cylinders. In some cases,

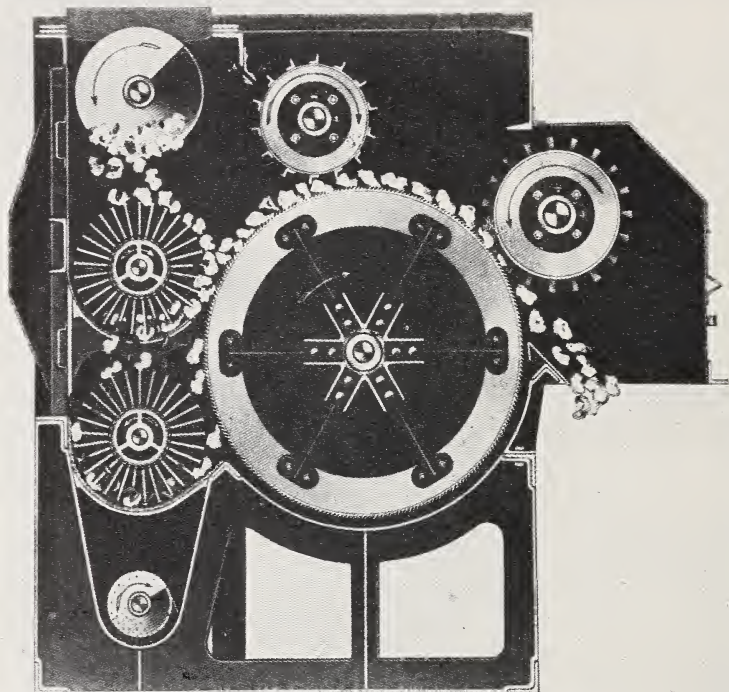


FIGURE 4.—Cross sectional view of a typical bur machine.

combined bur-extracting and large-size cylinder-cleaning units may be used instead of the separate machines just mentioned.

The next stage of cleaning comes in unit extractor-feeders after the bulk cotton is dropped into a conveyor distributor for distribution to the gins. The extractor-feeders, which are above each gin stand, may be either small or large unit extractors or a combination of two, placed one above the other. In some instances extractor-feeder units contain a cylinder cleaner attachment. These feeders, in many instances, may be provided with drying equipment which exerts a final conditioning action on the seed cotton. The extractor-feeder units are effective in removing burs, immature locks of cotton, and other foreign material left by the overhead cleaning machinery. From the extractor-feeders the cotton is fed to the gin stands at a controlled rate.

When the cotton enters the gin stand, the cleaning process is not finished. The gin stand itself is relatively effective in trash removal. The huller ribs, with which all gin stands of comparatively recent manufacture are equipped, remove burs, sticks, stems, and other large foreign matter in a very effective manner, and some of the moting processes which are incorporated in modern gin stands are very

efficient in removing motes and pin or pepper trash from the ginned lint.

Finally, in some cases, the lint is subjected to lint cleaning before being blown or drawn to the condenser. The lint cleaner is the latest development in gin cleaning machinery and has been subjected to extensive laboratory and field tests. It removes a very significant quantity of foreign matter, thereby improving the grade of the lint. It is designed primarily to remove fine leaf particles, motes, dust, sticks, and shale fragments, all of which affect the grade of the lint.

Modern cotton gins with their facilities for drying, cleaning, and bur extracting are equipped with various combinations of this equipment to meet the needs of the different regions of the Cotton Belt. Less than 2 percent of the gins in the Southeastern States were equipped with extractor-feeders in the late 1920's as compared with 56 percent in 1945. In the Mississippi Valley States, the proportion of gins so equipped increased from about 20 percent to 75 percent during this period. The gins in the western area are now equipped with extractor-feeders to about the same extent as are those in the Mississippi Valley States. The number of gin plants equipped with huller gins has increased materially, also, during the last 15 to 20 years. In 1945, almost two-thirds of the gins in the Southeastern States were of the huller type. In the remaining regions of the Cotton Belt, the proportion was close to 90 percent in 1945.¹

In addition to equipment such as hull extractor-feeders and huller front stands, the modern ginning establishment should have a seed cotton drier. Almost one-half of the active gins in the United States are equipped with a drier. These gins are the larger volume plants in most instances which, in the aggregate, gin considerably more than one-half of the crop. The proportion of gins equipped with driers varies from less than one-fourth for the Southeastern States, where many of the gin plants are of substandard types with relatively small volume, to more than two-thirds in the Far Western States, where most of the gins are modern, well-equipped plants. In the Midsouth almost three-fourths of the gins operate driers.

The use of overhead cleaning equipment has increased generally from east to west. In 1945, the proportion of gins equipped with overhead cleaners ranged from one-third in the Southeastern States to about 80 percent in the Southwest and Far West. The proportion of gins using overhead extractors for removing burs and large particles of foreign matter ranged from 7 percent to 58 percent for these two areas. More than one-fourth of the gins in the United States employed this equipment in 1945.

The extent to which mechanical pickers are used in the future will determine to a considerable degree the extent to which such equipment will be added to commercial gins. Already many ginners handling machine-picked cotton or otherwise trashy-picked cotton and others anticipating demands for service on increasing quantities of rough-harvested cotton are equipping their gins for these services in an effort to do a creditable job of cleaning and ginning.

¹ Bureau of the Census. Cotton Ginning Machinery and Equipment in the United States, 1945. Washington, 1946.

Although some improvements in seed-cotton cleaning equipment have been made during the last few years, ginner—in their efforts to do a better job of cleaning the rough-harvested cottons—have increased so greatly the number of driers, extractors, and cylinder cleaners in their gins that the fiber properties of the cotton may be adversely affected in some instances. Even so, the desired amount of cleaning has not been accomplished. Combinations of existing seed cotton cleaning and drying equipment remove much of the moisture from seed cotton and most of the large leaf trash, hulls, and burs. But some of the leaf trash is ground into the lint and is not removed in the cleaning process or with the motes in the gin stand. The limitations of seed-cotton cleaning equipment, both economic and mechanical, were foreseen by engineers and technologists of the U. S. Cotton Ginning Laboratory a number of years ago. This led to the investigation of methods for cleaning the lint between the gin stand and the condenser. The laboratory-designed flow-through lint-cotton cleaner resulted from this work.²

CLEANING PROCESS AS A FUNCTION OF THE COTTON GIN

During the last decade, the investment in cleaning and drying equipment in modern gins increased substantially. Ten years ago, a modern gin in the Southeastern States was commonly equipped with extractor-feeders and frequently had drying facilities, operated either as a separate unit or as an integral part of the feeders or of a cleaner. For the average 3-stand gin in the area, the value of this equipment represented less than 20 percent of the investment in the plant. Gins are being modernized still further, and new elaborately equipped plants have been installed in increasing numbers to handle the roughly hand-picked cotton that is being received at gins in large quantities. These plants, in many instances, are equipped with one more cleaner and sometimes one more drier, together with increased bur-extracting facilities, as compared with gins considered to be modern 10 years ago. At the present time the cost of such auxiliary cleaning and drying equipment and the extra power required is about one-third or more of the investment in the entire ginning plant.

In the Mississippi Valley States, the average gin that was modern in 1938 contained adequate provision for drying the cotton and had relatively extensive cleaning equipment. At the present time, it is not uncommon for a modern 1952 gin in that area to be equipped with 2 driers, 3 cleaners or their equivalent in cleaning cylinders in one or two units having as many as 30 cleaning cylinders, an overhead bur-extracting machine, and extra large extractor-feeders. Power units to drive the additional fans and auxiliary cleaning elements are double the size of those used in the 1938-model gins. During the last decade, the size of the gin building to house this equipment increased about 50 percent. The average modern gin in the Mississippi Valley now employs 4 gin stands as compared with 3 to 4 in 1938.

In the important cotton-producing sections of Texas and Oklahoma, principally south and west Texas and western Oklahoma,

² Stedronsky, Victor L., and Shaw, Charles S. The Flow-Through Lint-Cotton Cleaner. U. S. Dept. Agr. Cir. 858, 30 pp., illus. November 1950.

where snapping of cotton has been practiced for a long time and requirements for cleaning equipment have always been heavy, cleaning and extracting equipment has not increased materially in recent years. This is especially true in west Texas and western Oklahoma. However, there has been a tendency for ginners to increase their drying equipment. Most of the gin plants in the western area employ 5 gin stands in a single battery. There are a number of modern plants, valued at \$100,000 to \$150,000 each, operating in this area; and there are many new plants in the Mississippi Valley of comparable capacity. The equipment for cleaning and drying the rough-harvested cotton and the increased power facility and building space necessary to operate this equipment represent more than half the value of the entire plant.

Despite the rapid strides that have been made in recent years in improving the effectiveness and increasing the use of cleaning and drying equipment, the quality of the American cotton crop has declined in grade. The practice of rough harvesting has increased each year and the installation of gin-cleaning equipment has not kept pace with this change. In 1930-31 about 72 percent of the cotton produced in this country was Middling or better in grade as compared with 49 percent in 1952-53 (table 1). Some of this decrease in grade may be attributed to the breeding of early maturing cottons in an effort to combat insect damage and to the longer staple and finer fibers. Only 23 percent of the 1930-31 crop was 1 inch and longer in staple as compared with 72.3 percent in 1952-53. The longer, finer cottons are not as easily cleaned as the short, coarse-fibered cottons. However, much of this decrease in grade is due to rougher harvesting methods. One of the current problems of plant breeders is the breeding of cotton to meet requirements for mechanical harvesting and cotton from which the foreign matter may be removed more easily in the gin-cleaning process.

TABLE 1.—*Estimated percentages of the cotton crops of the United States that graded Middling white or extra white or better, and 1 inch or longer in staple, 1930-52*

Season	Middling and better white or extra white grade	1 inch and longer staple	Season	Middling and better white or extra white grade	1 inch and longer staple
	<i>Percent</i>	<i>Percent</i>		<i>Percent</i>	<i>Percent</i>
1952-53 ¹ ----	48. 9	72. 3	1940-41-----	55. 7	59. 8
1951-52-----	39. 4	73. 5	1939-40-----	51. 9	49. 3
1950-51-----	37. 9	76. 2	1938-39-----	55. 5	51. 4
1949-50-----	33. 8	65. 4	1937-38-----	44. 3	33. 6
1948-49-----	51. 4	76. 4	1936-37-----	54. 2	43. 0
1947-48-----	59. 7	66. 4	1935-36-----	57. 0	30. 9
1946-47-----	39. 3	77. 6	1934-35-----	76. 0	33. 0
1945-46-----	30. 7	70. 5	1933-34-----	55. 2	28. 5
1944-45-----	35. 4	65. 5	1932-33-----	64. 6	26. 8
1943-44-----	47. 1	57. 4	1931-32-----	74. 6	27. 0
1942-43-----	41. 9	61. 3	1930-31-----	72. 3	23. 0
1941-42-----	40. 7	62. 5			

¹ Preliminary.

If rough-harvesting methods are to continue to be economically feasible in view of the prevailing discounts on low-grade cotton, it is necessary that cotton be cleaned in the gins sufficiently to yield a much higher percentage of Strict Low Middling grade and above than has heretofore been the case under adverse conditions. To accomplish this, the movement toward improved ginning processes and more efficient cleaning facilities at the gins must be accelerated to keep ginning service in line with mechanical harvesting methods and practices. Economical layouts of seed cotton drying, cleaning, and extracting equipment to meet local needs are desirable under all conditions.

Good results are obtained in cleaning machine-picked cotton and even better results may be expected in the future, as machinery and techniques are improved. Grade differences between hand- and machine-picked cotton have, in only a few years, narrowed from 2 to 3 grades to about 1 grade. For example, tests conducted at the ginning laboratory over a period of 4 years on 5 varieties of cotton show that the average grade difference between hand- and machine-picked cotton is slightly more than 1 grade, when both are cleaned in the same manner. Field studies recently made in the Delta of Mississippi and the San Joaquin Valley of California confirm these results.³

PRESENT METHODS AND REQUIREMENTS OF SEED COTTON CLEANING TO MEET REGIONAL NEEDS

The type and amount of conditioning and cleaning equipment required in a cotton gin depend primarily on harvesting practices and on weather conditions in the area during the harvesting season. The amount of foreign matter in seed cotton varies widely with different harvesting conditions. Leaf-trash content of cotton increases as the season progresses. Toward the end of the season, cotton harvested by all methods contains some burs.

HARVESTING AND WEATHER AS RELATED TO PROBLEMS IN CLEANING

Hand-picking is still the predominating method of harvesting cotton in the Cotton Belt as a whole. Cotton thus harvested contains some leaf trash throughout the season and burs during the latter part of the season, and these present difficulties in cleaning. But hand-picked cotton contains virtually no sticks, stems, or grass. Hand picking yields higher grades than other methods and requires a minimum of seed cotton cleaning machinery.

Mechanically picked cotton frequently contains an excess of leaf trash but relatively few burs, sticks, and stems. The leaf trash is

³ Ross, John E., Jr., Fortenberry, William H., and Montgomery, Robert A. Costs and Quality of Cotton Ginning in Relation to Method of Harvesting and Type of Ginning Equipment, Yazoo-Mississippi Delta, Seasons 1946-47 and 1947-48. U. S. Dept. Agr. 54 pp. April 1949.

Bailey, Warren R., and Hedges, Trimble R. Economics of Mechanical Cotton Harvesting, Study Made in San Joaquin Valley 1949-50. Calif. Agr. Ext. Serv. 9 pp. 1951.

green when the plants are not defoliated, and dry and brittle when the plants are properly defoliated or when the foliage is killed by frost prior to the picking of cotton.

Grass and weeds included with the seed cotton picked from grassy fields are very objectionable as there are no seed cotton cleaners or combinations of cleaning machinery either at the gin or in the cotton mill which will effectively remove all of this type of foreign matter from the cotton. Therefore, cotton which is classed "grassy" is penalized severely when sold.

Very often, mechanically picked cotton contains an excess of moisture, as compared with hand-picked cotton, as a result either of natural conditions or the addition of moisture applied to the spindles or doffing mechanism to facilitate picking. Laboratory tests showed that the moisture content of machine-picked cotton will average from 2 to 5 percent higher than that of hand-picked cotton when both are harvested from the same field at the same time.

Mechanical stripping and hand snapping are practiced in west Texas and western Oklahoma, and to some extent in other areas. Cotton harvested in this manner contains a preponderance of burs, sticks, stems, and dry leaf trash. Green bolls and some green leaf trash also present a problem when cotton is machine stripped early in the season.

Foreign matter in relatively clean hand-picked cotton ranges from 15 to 40 pounds of the weight of seed cotton per bale; in roughly hand-picked cotton, 50 to 150 pounds; in mechanically picked cotton, 25 to 75 pounds; and in mechanically stripped cotton, 800 to 1,200 pounds. However, seed cotton lots that contain the different types of foreign matter can be so cleaned that they will produce ginned lint samples with a relatively narrow range of foreign matter content, but with a quality range that may vary by several grades. Fine particles of trash and vegetative matter that adhere to the fibers, particularly to mechanically picked cotton, detract from the grade. Shirley Analyzer tests show that in a 500-pound bale of cotton, the foreign matter ranges from 10 to 20 pounds for clean hand-picked cotton, from 20 to 30 pounds for rough hand-picked cotton, from 20 to 40 pounds for snapped cotton, from 20 to 40 pounds for mechanically picked cotton, and from 30 to 60 pounds or more for machine-stripped cotton.

Climatic conditions vary widely across the Cotton Belt, especially as to rainfall. Rainfall influences the variations in moisture in seed cotton as it comes to the gin and, in turn, the drying necessary to condition the cotton effectively. Harvesting practices also influence, to some extent, the moisture in the seed cotton. But the differences are relatively small when considered on a seasonal basis for a given area if hand harvesting is begun shortly after rains and early in the season, when it is impractical to use mechanical methods of harvesting.

BASIC CONSIDERATIONS IN PROVIDING SEED COTTON CLEANING FACILITIES

For the purpose of setting general guides for the basic minimum gin needs of those who plan to build new plants or to modernize existing ones, the Cotton Belt has been divided into six areas, con-

sideration being given as far as possible to all factors affecting ginning. Each of these areas includes in most instances parts of a number of States which in some cases are remote from each other geographically but are surprisingly similar as far as the needs for conditioning and cleaning equipment are concerned (fig. 5).

An analysis of the results of studies on the cost of ginning in various sections of the Cotton Belt shows that the "break-even" point, considering ginning revenue only, for gins recommended for the various areas will range from 1,800 to 2,000 bales in Area 1; from 2,000 to 2,500 bales in Area 2; from 2,300 to 2,800 bales in Area 3; from 2,500 to 3,000 bales in Areas 4 and 5; and from 2,800 to 3,200 bales in Area 6. In any area there should be a minimum volume of 500 bales per gin stand when considering the size of plant needed to handle the anticipated volume. There are problems peculiar to each gin installation and these figures are not expected to cover all cases. They are offered as a guide for those who are building new plants or modernizing existing ones in an attempt to render the service expected of up-to-date, progressive gins.

Harvesting practices by the potential customers, climatic conditions during the harvesting season, and possible future trends in methods of harvesting and cotton production must be considered in building or altering plants. Frequently gins, even in the same general locality, must cope with different problems. The recommendations set forth in this publication are based on comprehensive laboratory and field studies, and represent what is considered the minimum equipment for doing a creditable job of conditioning, cleaning, and ginning. Lint cleaners are optional for the machinery setups mentioned in this discussion. It is fortunate that, as cleaning machinery requirements for handling mechanically harvested cotton increase, the plants that are equipped adequately to handle late-season rough hand-harvested cotton will be in a favorable position.

Area No. 1 is comprised of the western halves of North Carolina and South Carolina, east Tennessee, the northern half of Georgia, central Alabama, northeastern Mississippi, south central Missouri, the western half of Arkansas, northwestern Louisiana, east Texas, and the eastern half of Oklahoma. For the most part, these sections are made up of family-size farms employing a minimum of transient labor for harvesting the crop. Relatively clean hand-harvesting methods predominate and the crop is usually out of the field before heavy winter rains, thus eliminating excessive weather damage. With the exception of early season green cotton and dew-laden cotton resulting from early morning harvesting, moisture does not often present a serious problem at the gin. A minimum of cleaning and conditioning equipment is necessary to produce a satisfactory sample of lint cotton in this area because of the generally good condition of the cotton received at the gin. Usually a small amount of drying, such as is done by a 9- to 11-floor tower or its equivalent, followed by cleaning with a cylinder cleaner and extractor-feeders over huller front gin stands, will, under most conditions, result in a creditable job of conditioning, cleaning, and extracting, and produce a bale of good market value thereby satisfying both farmer and ginner (fig. 6).

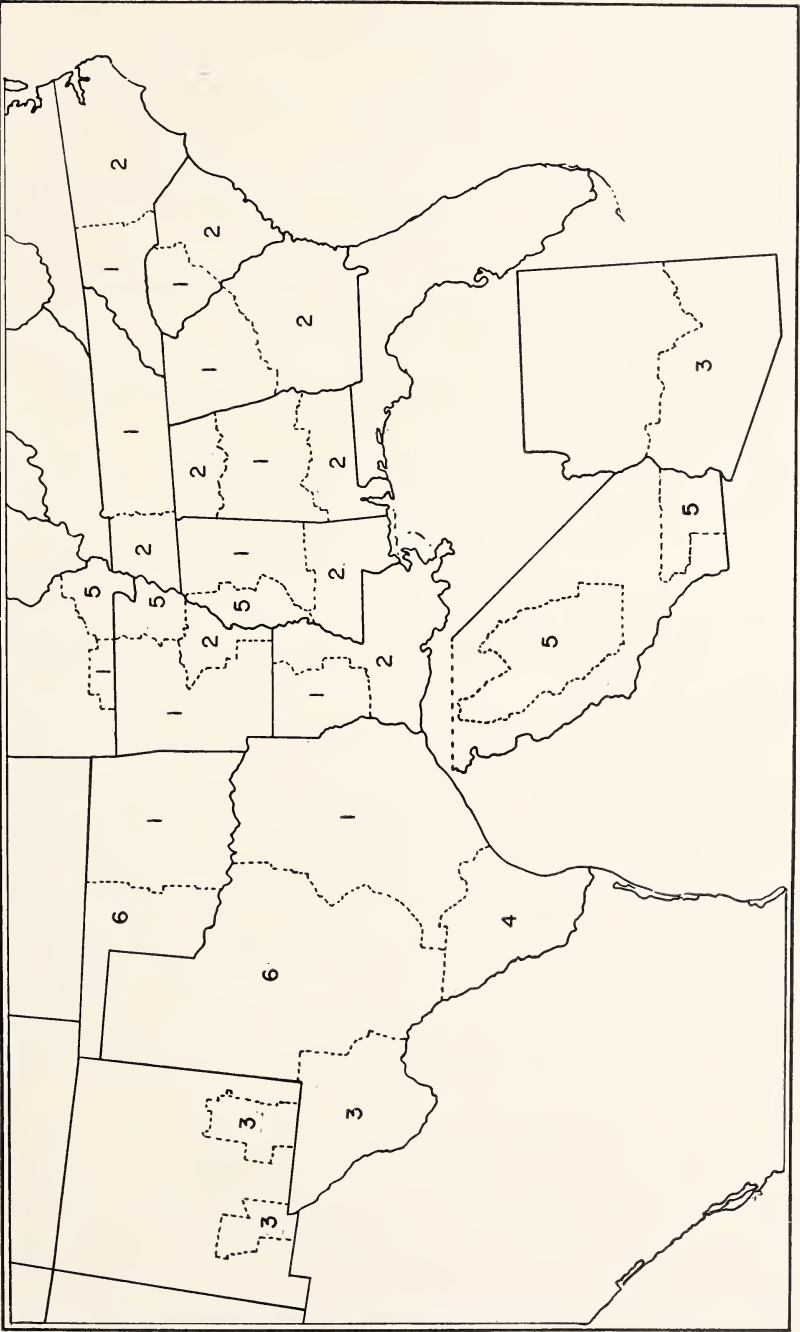


FIGURE 5.—Areas of the Cotton Belt that are similar from the standpoint of minimum cotton conditioning and cleaning requirements.

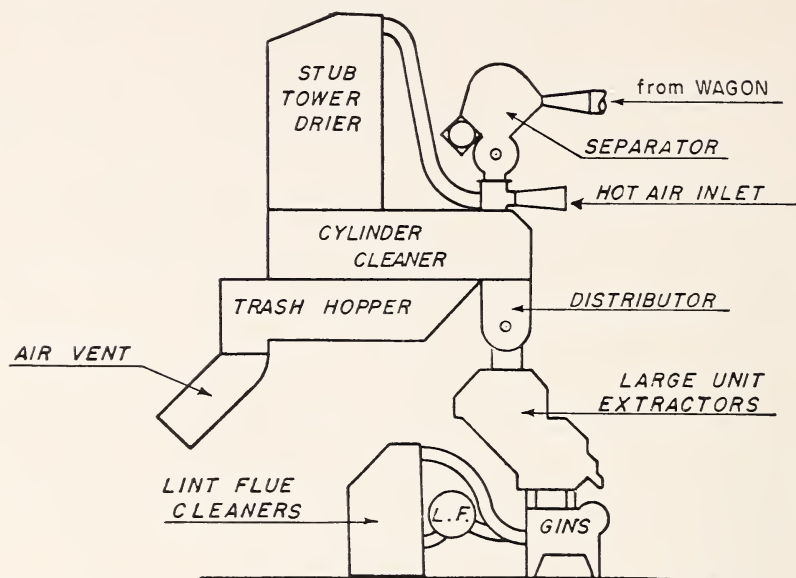


FIGURE 6.—Minimum seed cotton cleaning machinery recommended for the western halves of North Carolina and South Carolina, east Tennessee, the northern half of Georgia, central Alabama, northeastern Mississippi, south central Missouri, the western half of Arkansas, northwestern Louisiana, east Texas, and the eastern half of Oklahoma.

Area No. 2 is comprised of eastern parts of North Carolina and South Carolina, southern Georgia, northern and southern parts of Alabama, western Tennessee, southeastern Arkansas, southern Mississippi, and southern and eastern Louisiana. This area is similar to Area No. 1 except that the amount of moisture encountered during the harvesting season is greater, mostly because of high humidity and heavy dews. Rains resulting from coastal storms also present a moisture problem in North Carolina, South Carolina, and Georgia. As a result of the relatively high moisture content of the seed cotton as it comes to the gin, a full-size tower drier or its equivalent is necessary to condition the cotton properly before it is cleaned. After the cotton has been dried, a cylinder cleaner with large-size extractor feeders over huller front gin stands will remove enough bur and leaf trash to give a good lint sample under most conditions existing in the area (fig. 7).

Area No. 3 includes the El Paso section of Texas and the cotton-growing sections of New Mexico and Arizona. In this very dry climate most of the cotton is grown under controlled conditions by irrigation. There is very little weather damage in the field as compared with other areas and practically the entire crop will fall within the extra white grades. Excessive moisture is very seldom a problem. On the contrary, the lack of moisture in the seed cotton and the atmosphere creates a static electricity problem at times. The static electricity causes chokages in the various cleaning and extracting units and inhibits the effectiveness of the cleaners for trash

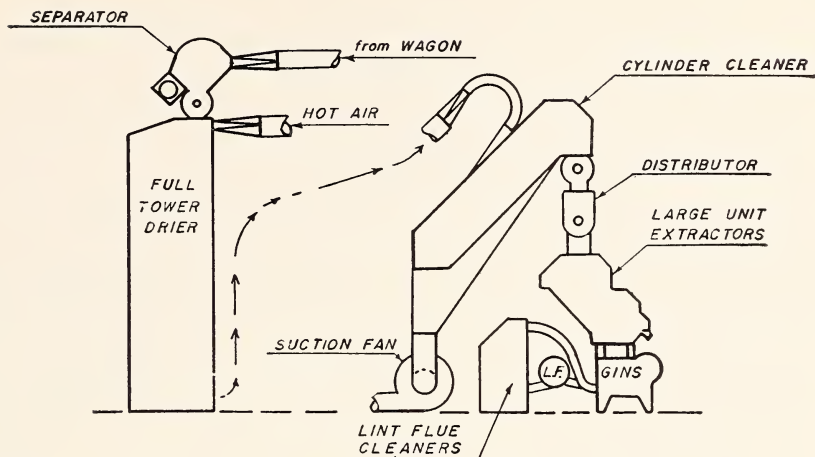


FIGURE 7.—Minimum seed cotton cleaning machinery recommended for eastern parts of North Carolina and South Carolina, southern Georgia, northern and southern parts of Alabama, western Tennessee, southeastern Arkansas, southern Mississippi, and southern and eastern Louisiana.

removal. Much of the cotton is harvested by machines or by transient labor and contains a large amount of foreign matter which must be removed by the cleaning and extracting machinery at the gin.

Although as a rule the seed cotton is relatively dry when it comes to the gin, some drying may be necessary early in the season. A 9- to 11-floor tower drier or its equivalent, a 5- to 7-cylinder cleaner, a bur machine, followed by 10 to 14 cylinders of cleaning and large-size extractor-feeders over the gin stands will give adequate drying, extracting, and cleaning to meet the requirements of the ginner in most instances (fig. 8). The drier installation should be such that it may be bypassed when excessive static conditions exist. This is necessary because the exposure of the seed cotton to the very dry air as it passes through the drier, even though no heat is being used in the drier, will tend to reduce further the moisture content of the seed cotton and aggravate the static condition.

Area No. 4 consists of the lower Rio Grande Valley and Corpus Christi, Tex., section which, by comparison, comprises a very small part of the Cotton Belt and one quite different in a number of details. This is one of the newest cotton-growing sections of the country. Cotton production in this section expanded rapidly from 1945 through 1949. The ginning season is very short owing to the deadline plow-up date required by the pink boll worm quarantine regulations. To speed up harvesting, rapid methods such as pulling and snapping are employed even during the early part of the season when the seed cotton is green and damp. This green cotton, together with an excessive amount of foreign matter resulting from the rough harvesting methods, presents a difficult problem at the gin. As a general rule, there is very little rainfall during the short harvesting season and the cotton dries rapidly in the fields after it has opened, but picking usually keeps almost current with the opening of the bolls so that some green cotton is brought to the gin throughout most of the ginning season.

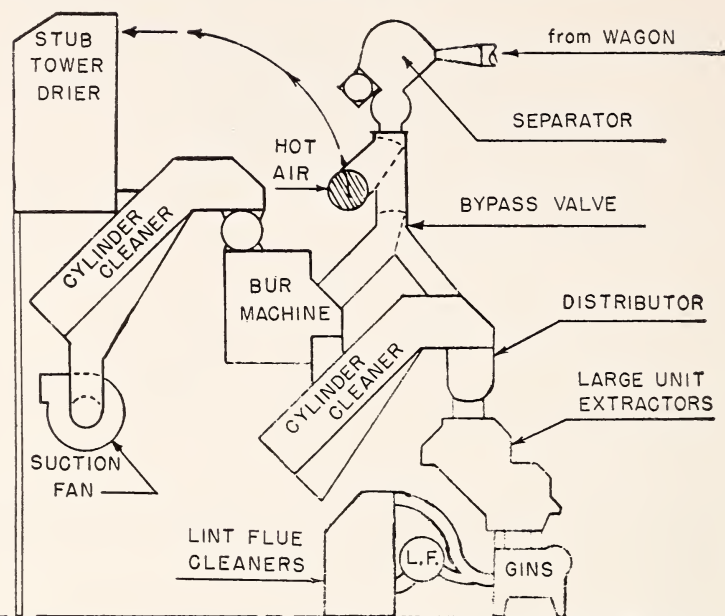


FIGURE 8.—Minimum seed cotton cleaning machinery recommended for the El Paso section of Texas and the cotton-growing sections of New Mexico and Arizona.

To condition this green cotton for proper cleaning and ginning, it is necessary to use a full-length tower drier or its equivalent. In addition, the cotton should be put through a cylinder cleaner, a full-size bur machine or its equivalent, a second cleaner, and large-size extractor-feeders located over the gin stands to insure the removal of sufficient quantities of the foreign matter from the seed cotton and thus obtain a lint sample of good market value (fig. 9).

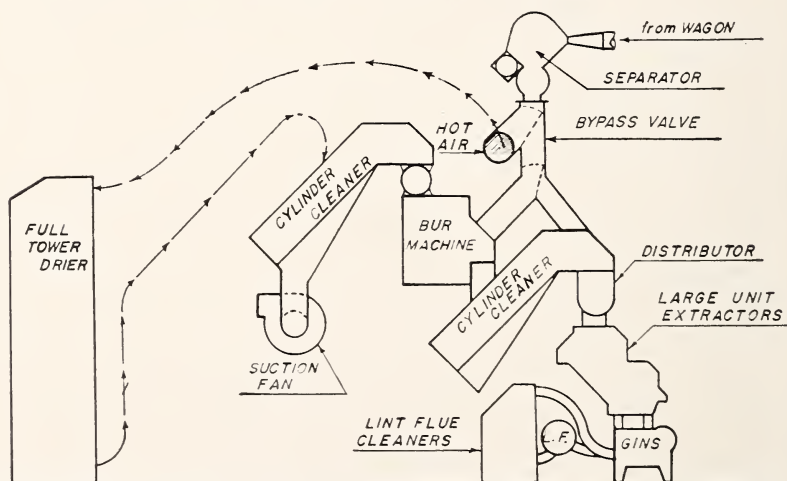


FIGURE 9.—Minimum seed cotton machinery recommended for the lower Rio Grande Valley and Corpus Christi, Tex., section.

Area No. 5 consists of the cotton-growing section of southeastern Missouri, northeastern Arkansas, the Delta section of Mississippi, and the cotton-growing sections of California. This area, with the exception of California, comprises what is thought of as the heavy producing rain-grown-cotton section of the Belt. The growth is usually very rank and the cotton opens rather slowly when defoliant is not used. Rainfall is usually heavy, especially during the latter part of the long harvesting season. As a result of the rank growth and heavy rainfall, the open cotton deteriorates very rapidly in the field, generally about one grade per month, with a corresponding shortening of staple length which amounts to about one-thirty-second inch a month. Cotton harvested before November 1 usually escapes much of this damage.

During the period of World War II, a shortage of hand labor forced producers to resort to rough harvesting methods in an effort to harvest the crop. The number of mechanical pickers increased much more rapidly than would have been the case under normal conditions, and efforts were made to obtain as much transient labor as possible to assist in the harvest. Many of the gins were not adequately equipped to handle, without serious losses in grade, the rough hand-harvested and machine-picked cotton thus obtained. When gin cleaning machinery became available after World War II, gin plants were built and additional machinery was added to existing gins in an effort to remove enough foreign matter from the seed cotton to avoid serious discounts resulting from very low grades.

The cotton grown in California is irrigated. Much of the weather damage encountered in other sections is avoided in this State except during the latter part of the season, but harvesting methods are about the same as those in the Mississippi Delta and the quantity of foreign matter present in the seed cotton as it reaches the gin is comparable. The two sections—the Mississippi Delta and California—have similar problems with respect to moisture in the seed cotton. The heavy fogs that prevail in California during the latter part of the season and the rains that follow aggravate the problem of moisture in cotton in that State. Heavy rains make the problem difficult in the Mississippi Delta region.

Laboratory and field tests show that a relatively large amount of seed cotton drying, cleaning, and extracting equipment is necessary to condition the cotton and remove sufficient foreign matter from the seed cotton to avoid heavy discounts in lint quality. It has been found that a tower drier or its equivalent, a cylinder cleaner, a full-size bur machine or its equivalent, a second tower drier or its equivalent, a second cleaner, and large-size extractor-feeders over huller front gin stands are desirable in drying and cleaning cotton found in Area 5, in order to produce a lint sample of satisfactory quality (fig. 10).

Area No. 6 is composed of western Oklahoma and western Texas, exclusive of the El Paso section. The cotton in this area is produced both under irrigation and by dry-land farming methods. There is almost no rainfall during the harvesting season. Most of the cotton is hand-snapped during the early part of the season, strippers being pressed into service after frost. This is the only area in which mechanical stripping is practiced to a large extent. As a result of the normally dry climatic conditions, the cotton reaches the gin relatively

dry. There is very little deterioration in the field. The burs are firm and although some are green and unopened, they do not break up in the cleaning machinery as they do in the more humid sections of the Belt. The type of cotton grown, the condition of the foreign matter, and the low moisture content of the cotton when it comes to the gin, all tend to contribute to relatively easy foreign matter removal by the seed cotton cleaning equipment.

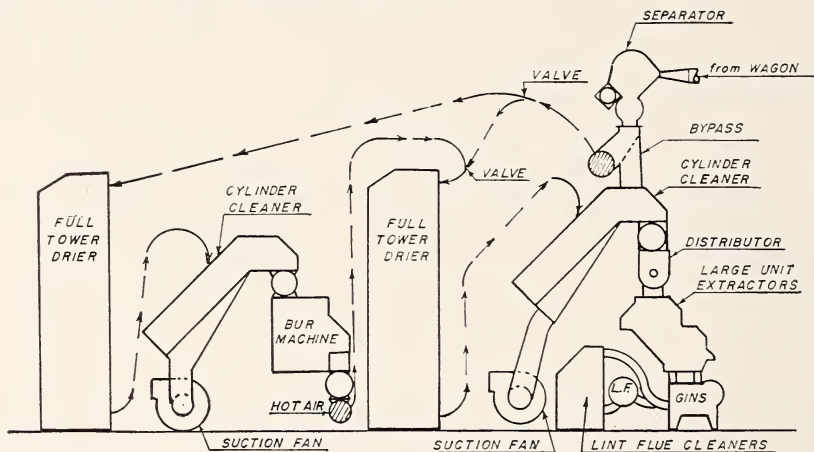


FIGURE 10.—Minimum seed cotton cleaning machinery recommended for the cotton-growing section of southeastern Missouri, northeastern Arkansas, the Delta section of Mississippi, and the cotton-growing sections of California.

To cope with the large amount of foreign matter that must be removed from the seed cotton in Area 6, a gin should be equipped with a screen-type cleaner, a tower drier or its equivalent, a full-size bur machine or its equivalent, a cylinder cleaner, and large extractor-feeder cleaners over the huller front gin stands (fig. 11). It is rec-

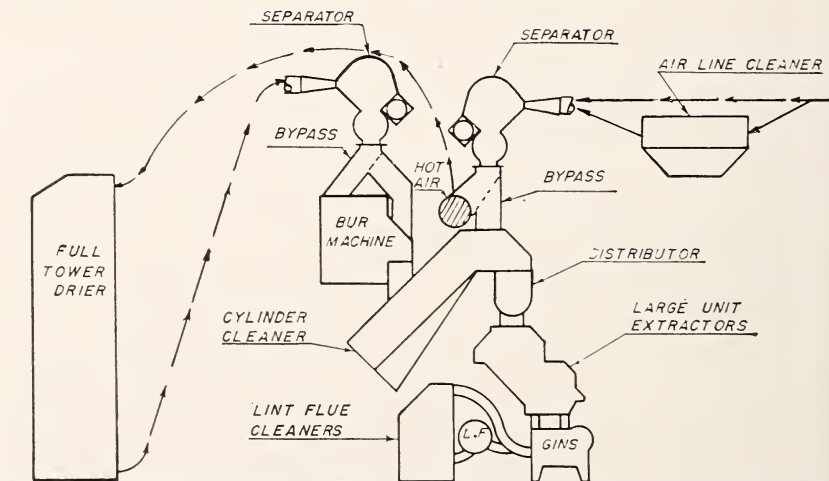


FIGURE 11.—Minimum seed cotton cleaning machinery recommended for western Oklahoma and western Texas, exclusive of the El Paso section.

ommended that gins in all other areas be equipped with a seed cotton drier preceding the cleaning machinery so that the cotton may be conditioned for more effective trash removal. The large quantity of sand present in the seed cotton of Area 6 as it comes to the gin makes it advisable to place an air-line cleaner ahead of the drier. This removes much of the sand. In this way the excessive wear which would result from the abrasive action of sand in the cleaners and cotton handling system may be avoided. At times, static electricity is a problem in Area 6 gins during periods of very low relative humidity, and for this reason the arrangement of the piping system should be such that the drier may be bypassed. It has been found that passing dry seed cotton through a drier even without heat will aggravate the static condition during a period of low humidity.

The individual ginner may find necessary some variations in the requirements here set down. In general, however, these recommendations apply appropriately to the several sections of the Cotton Belt.

LIMITATIONS OF EXISTING SEED COTTON CLEANING PROCESSES AT GINS

Over a period of years, the engineers and technologists of the U. S. Cotton Ginning Laboratory have carried out comprehensive seed cotton cleaning tests. All existing types of seed cotton cleaning machines were tested to determine the most effective cleaning combinations and their effect on the fiber and spinning quality of the lint. Machine-picked cotton has been used in many of these tests, especially in recent years. The quantity of machine-picked cotton has been relatively small in proportion to the remainder of the crop; however, the problems it presents in the gin are comparable to those presented by rough hand-harvested cotton. Thus far, the methods and equipment that have been found effective in handling, cleaning, and ginning mechanically harvested cottons are not materially different from those used satisfactorily for rough hand-harvested cottons.

Seed cotton cleaning tests on 3 varieties of cotton covering a period of 2 years show that machine-picked cotton of normal moisture content can be put through as much as 24 cylinders of cleaning, a bur machine, and extractor-feeders after having been dried through a tower drier—or the equivalent of this treatment in drying, cleaning, and extracting equipment—without excessive damage to the spinning qualities of the cotton (table 2). A simple cleaning setup consisting of a drier, 6 cylinders of cleaning, and extractor-feeders removed 53 percent of the foreign matter in the seed cotton as compared with 69 percent removed by the more elaborate setup which included a drier, 24 cylinders of cleaning, a bur machine, and extractor-feeders. The grade difference in cotton cleaned in the simple setup and that cleaned in the more elaborate setup amounted to one-third of a grade, which means that, on the average, 30 to 35 bales out of each 100 ginned with the more elaborate ginning setup will be raised a full grade over that ginned with a minimum of cleaning equipment.

There is a tendency for the staple length to be reduced when the elaborate equipment is used, and the number of neps in the card web increases with the intensity of cleaning. The presence of excessive neps in the card web is very undesirable from a manufacturer's standpoint (fig. 12). These undesirable effects of elaborate cleaning

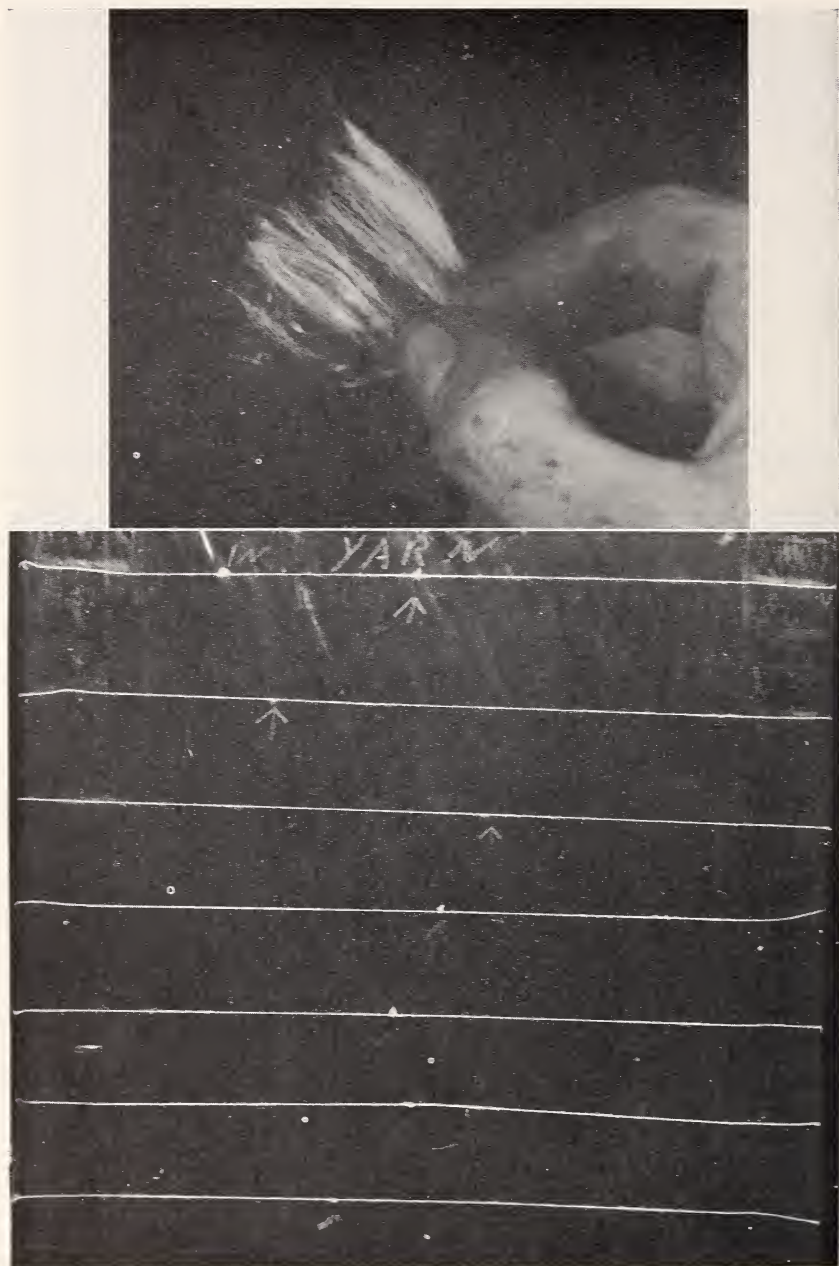


FIGURE 12.—Neps cause imperfections and reduce the quality of cotton yarn. Top: Neps as they appear in raw cotton. Bottom: Appearance of neps in cotton yarn.

TABLE 2.—*Effects of drying and cleaning machine-picked cotton by different methods with respect to the moisture content, foreign matter content, classification, and fiber and spinning data*¹

Cleaning setup ²	Moisture content			Foreign matter content			Classification		Fiber data		Spinning data									
	Wagon sample	Feeder sample	Lint	Cotton-seed	Wagon sample	Feeder sample	Lint	Amount removed by cleaners	Grade ³	Staple length	Upper half mean	Uni-formity ratio	Strength	Manu-factur-ing waste	Yarn strength		Yarn ap-pearance ⁴		Neps in the card web	
															22s	36s	22s	36s		
	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Design- ation	Index	1,000 lb. per sq. in.	Inches	Index	78	12.2	Pounds	Index	100	Index	Number	
Simple-----	12.3	10.2	6.4	12.0	6.5	3.0	7.6	53	84.6	LM +	37.4	1.17	78	76	12.2	119	66	100	100	26
Moderate-----	12.3	9.4	5.4	11.5	6.5	2.2	6.4	66	86.8	LM +	37.3	1.15	78	76	11.4	119	65	100	90	30
Elaborate-----	12.3	9.4	5.6	11.8	6.5	2.0	5.7	69	88.3	LM +	37.3	1.15	78	77	11.2	119	65	100	90	31

¹ Average of 2 years' data on 3 varieties of cotton ginned in 3 replications.² Simple cleaning setup: Tower drier 160° F., 6-cylinder cleaner, extractor-feeders.

Moderate cleaning setup: Tower drier 160°, 6-cylinder cleaner, bur machine, 6-cylinder cleaner, extractor-feeders. Elaborate cleaning setup: Tower drier 160°, 12-cylinder cleaner, bur machine, 12-cylinder cleaner, extractor-feeders.

³ 82=LM-; 85=LM; 88=LM+.⁴ 100=C+; 90=C.

of the cotton are not particularly detrimental when they have not progressed any further than is shown in this particular series of tests. However, the cotton begins to take on a "machined" appearance which causes buyers to become skeptical of it and to view it with suspicion.

The results of these and other similar tests and observations indicate that one-third to one-half grade improvement is all that can normally be expected from elaborate seed cotton cleaning on medium to long staple cotton, without causing harmful effects on the spinning quality of the lint. Furthermore, it appears that it is not advisable, at present, to subject the seed cotton to more than 24 cylinders of cleaning, or their equivalent, together with a drier, bur machine, and extractor-feeders.

Laboratory tests show that in order to insure maximum cleaning and to utilize the various machines to the fullest extent, the various seed cotton cleaning and extracting units in the gin must be properly arranged (table 3). It was found that a combination consisting of drying, cleaning, extracting, and cleaning was the proper sequence of processes for obtaining maximum cleaning effectiveness. Grade benefits averaging one-third of a grade were realized when this cleaning combination was used, as compared with a setup that utilized the same kind of machines but in which the cotton passed through the bur machine before it passed through any of the cylinder cleaners. A cleaning process in which a cleaner was used ahead of the bur machine removed 14 percent more foreign matter than a cleaning combination in which the cotton was subjected to the action of the bur machine first.

TABLE 3.—*Effects of two combinations of the same amounts of seed cotton cleaning machinery on the moisture content, foreign matter content, and classification of machine-picked cottons*¹

Cleaning setup	Moisture content			Foreign matter content			Classification		
	Wagon sample	Feeder sample	Lint	Wagon sample	Feeder sample	Amount removed by cleaning	Grade ²		Staple length
	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Percent	Index	Designation	½ inch
Tower drier 160° F., bur machine, 7-cylinder cleaner, extractor-feeders-----	12.2	11.0	7.6	7.8	3.3	57.7	88.9	LM+	34.4
Tower drier 160° F., 7-cylinder cleaner, bur machine, extractor-feeders-----	12.2	9.4	5.8	7.8	2.2	71.8	91.0	SLM-	34.6

¹ Data represent the average of 4 series of tests.

² SLM=Strict Low Middling=84; LM=Low Middling=85.

These and subsequent tests have indicated that in a cleaning setup the cotton coming from the wagon should pass through a drier before being subjected to the cleaning or extracting machinery. The amount of heat applied in the drier should depend on the moisture content of the seed cotton. From the drier the cotton should be blown and/or drawn into a cylinder cleaner by the use of the heated air from the drier. This exposes the cotton to the hot air for a longer period of

time and dries it more effectively, as evidenced by the fact that 1½ percent more moisture was removed from the seed cotton when the cleaner was utilized for drying. The drying air, exhausted through the screens of the cleaner, carries the dislodged trash away from the seed cotton. The cleaner also opens up and spreads large masses of cotton coming from the wagon, thus allowing a more even flow of cotton to the bur machine. This minimizes chokage and allows the bur machine to operate more effectively than would otherwise be the case. From the bur machine the cotton passes to the remaining cleaners before entering the extractor-feeders.

In some sections of the Cotton Belt, west Texas in particular, seed cotton includes large quantities of sand. When this condition exists, it is necessary to place an air-line cleaner in the suction line from the wagon telescope ahead of the drier in order that a large part of the sand may be removed before the cotton is put through the drying and cleaning operations. (See fig. 11.)

Many laboratory tests made at Stoneville in 1949 indicated how much cotton could be dried during ginning without serious adverse effects on lint quality. These tests provided for precise evaluations of the effects of drying on fiber quality and spinning value. A series of green and damp, early season, hand-picked seed cottons and a series of damp, midseason, machine-picked seed cottons were subjected to different methods of drying prior to ginning, and the ginned lint was tested for fiber and spinning properties. Single-stage dryings were made on each at drying air temperatures of 180°, 220°, 260°, and 350° F. Also, cotton was dried with three driers at moderate, high, and very high drying air temperatures, the first drier being operated with temperatures ranging from 180° to 280°, the second with temperatures of from 160° to 260°, and the third with temperatures of from 140° to 200°.

The moisture content of the ginned lint of hand-picked cotton decreased as higher drying air temperatures were employed in single-stage drying—from 6.5 percent at a temperature of 180° downward to 5.2 percent at 350° F. (fig. 13). Triple-stage drying at moderate temperatures produced a noticeable reduction in moisture content to 5.1 percent and at high temperatures, a further reduction to 4.5 percent. Cotton dried at the higher temperatures improved one-third grade and contained less lint moisture than cotton dried at lower temperatures. There was a tendency for length and, to some extent, fiber-length uniformity and tensile strength to become increasingly lower under more intense drying. It is doubtful whether value benefits from the grade improvements would offset value losses associated with reductions in weight and discounts for lowered fiber quality. The increasing losses in moisture content and fiber length attributable to more intense seed cotton drying appeared to be associated with proportionate adverse effects on yarn strength (fig. 14). In many instances, yarn appearance grade showed deficiencies on the overdried cotton.

The tests on hand-picked cotton showed that intense drying of clean cotton produced doubtful over-all benefits. However, this drying improved grade benefits on machine-picked cotton considerably because it facilitated the process of trash removal by the cleaners (fig. 15). In general, the greater the amount of moisture removed by

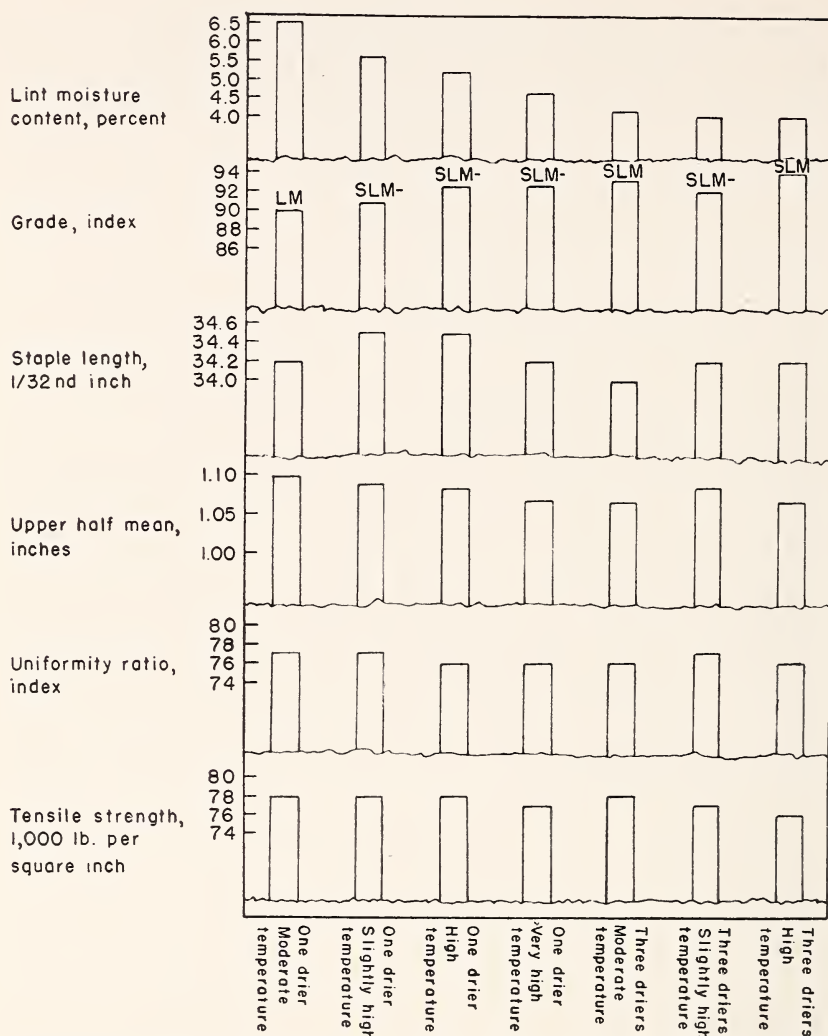


FIGURE 13.—Effects of different seed cotton drying practices on lint moisture content, classification, and fiber quality of early season hand-picked cotton.

increased drying, the higher was the grade of resulting ginned lint. This increase in grade ranged from Low Middling plus for cotton dried least, in one drier, to Strict Low Middling for the cotton dried most, in three driers. Fiber laboratory tests showed that there were slight but consistent reductions in fiber length and strength of cotton when three driers were used and the lint moisture content was reduced to nearly 4 percent, compared with 6.3 percent for single-stage drying at moderate drying air temperatures. The spinning test results confirmed the fiber test data; they showed that although drying was a factor in reducing manufacturing waste, cotton dried excessively had

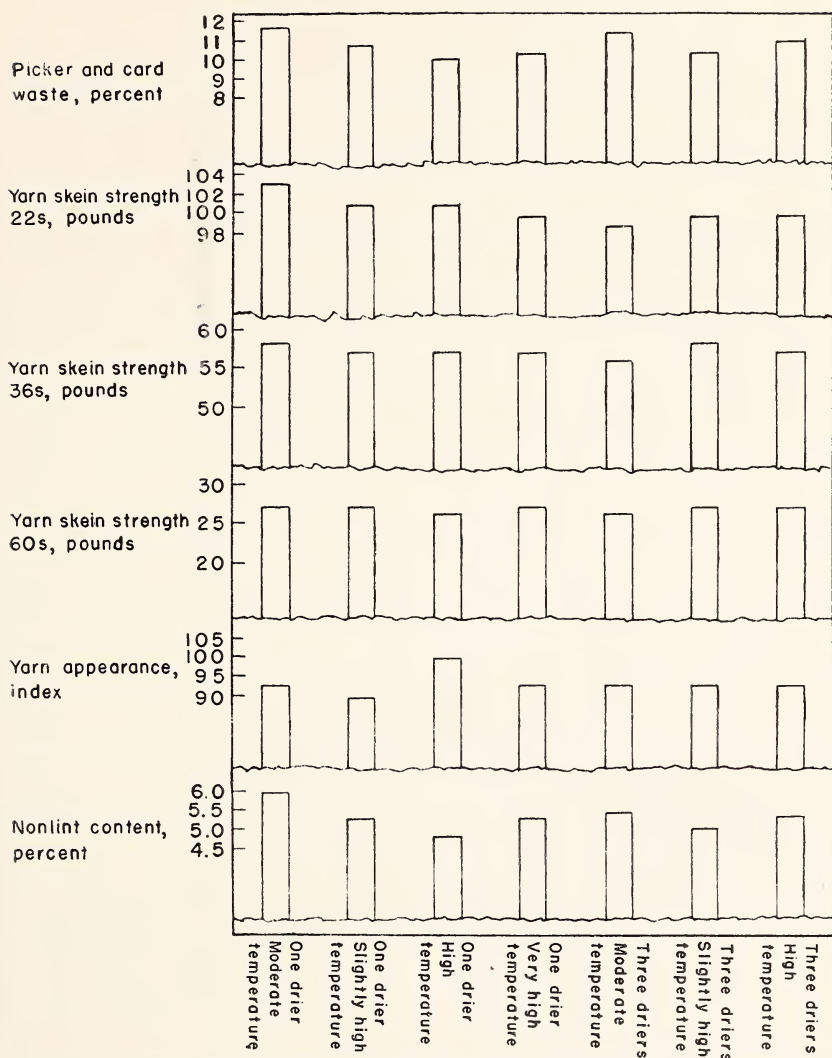


FIGURE 14.—Effects of different seed cotton drying practices on manufacturing performance and carded yarn quality of early season hand-picked cotton.

a tendency to be lower in yarn strength and appearance grade (fig. 16). The best results with respect to the grade, fiber properties, and spinning quality of damp, machine-picked cotton were obtained when it was dried with the single-stage drying process under drying air temperatures of 220° and 265° F.⁴

⁴ Gerdes, Francis L. Cotton Drying Practices in Relation to Quality and Efficiency of Ginning. The Cotton Ginners' Journal Yearbook. Texas Cotton Ginners' Assn., Dallas, Tex. March 1950.

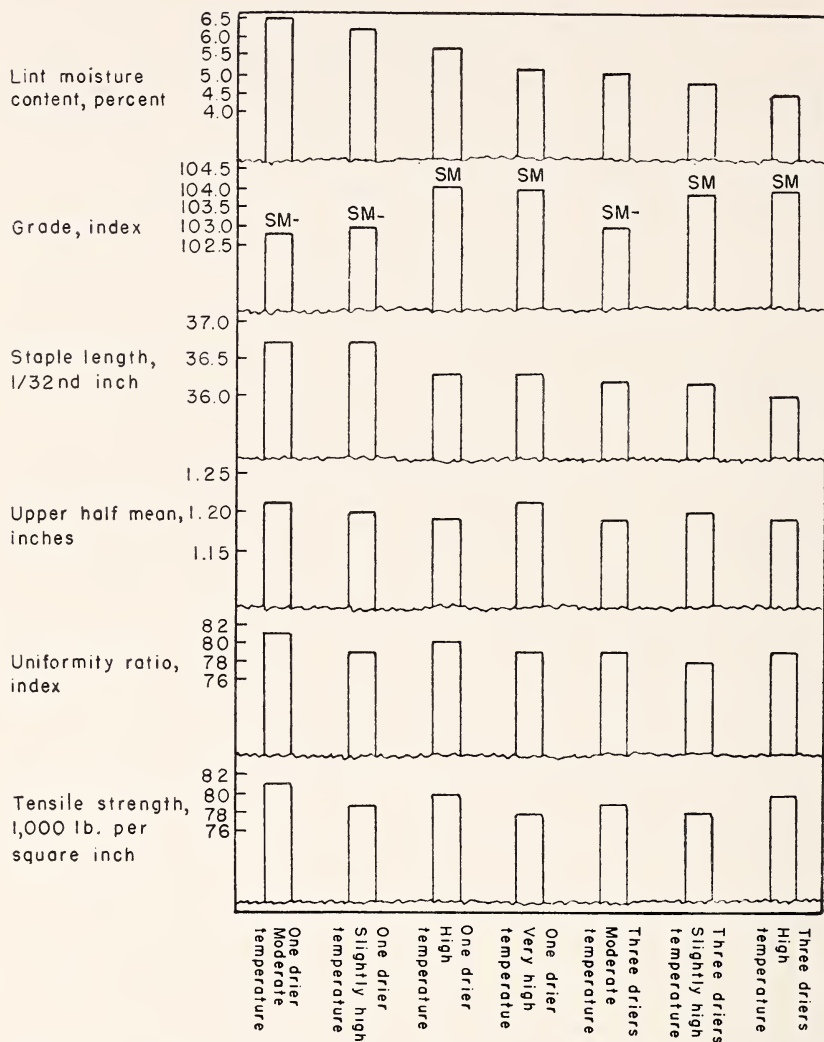


FIGURE 15.—Effects of different seed cotton drying practices on lint moisture content, classification, and fiber quality of midseason machine-picked cotton.

Proper drying is essential to efficient and effective cleaning. Provisions for adequate drying facilities should be included in the machinery plans for new gins or in the modernization of existing ones.

ADAPTING CONVENTIONAL LINT CLEANERS TO THE GINNING PROCESS

Realizing that existing seed cotton cleaning equipment must be improved in order adequately to clean rough-harvested cottons, the U. S. Cotton Ginning Laboratory and gin equipment manufacturers

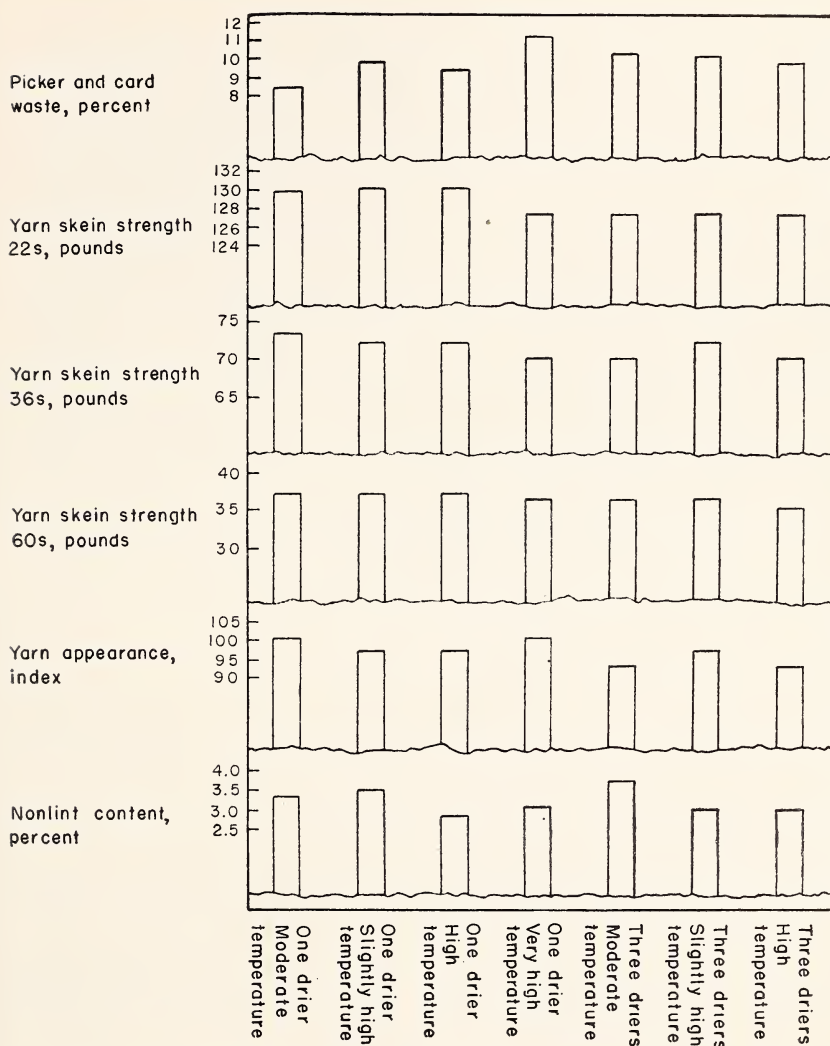


FIGURE 16.—Effects of different seed cotton drying practices on manufacturing performance and carded yarn quality of midseason machine-picked cotton.

have developed effective continuous-process lint-cleaning machines for use in cotton gins. In the design and development of lint cleaners, provision was made for mechanical and installation features that would permit the adaptation of the machines to both old and new gin plants. The leading gin manufacturing companies are producing lint cleaning machinery and the use of these machines has increased rapidly since they were placed on the market. Their performance proves that lint cleaning has a definite place at gins to supplement seed cotton cleaning machinery in handling machine-picked and rough-harvested cotton. According to sales reports from gin manu-

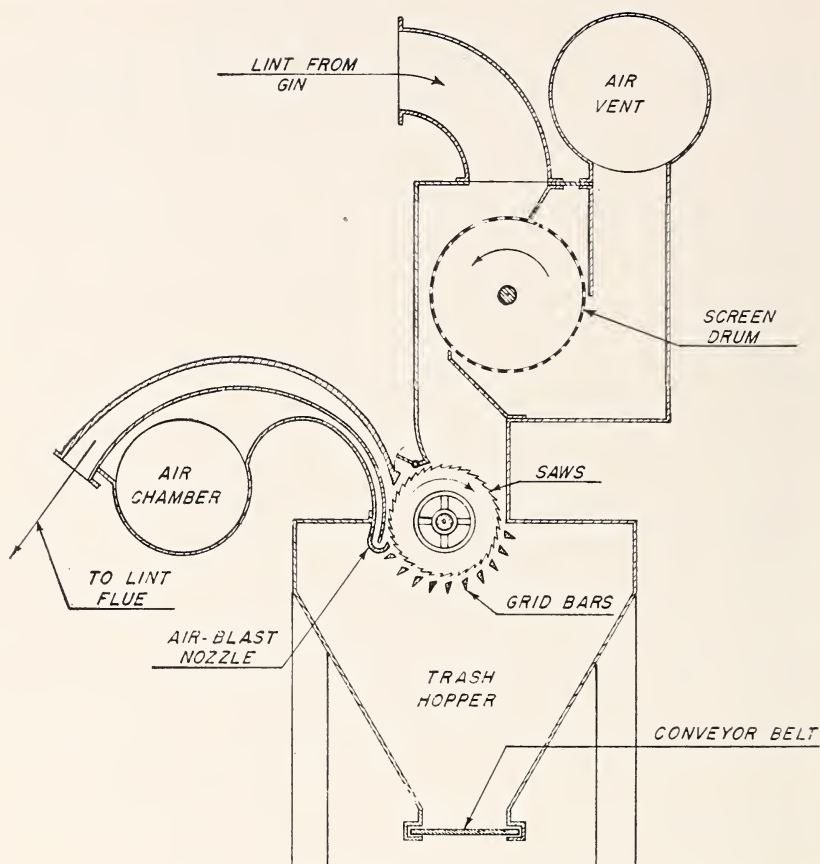


FIGURE 17.—Cross sectional view of the final model of the lint cleaner designed by the U. S. Cotton Ginning Laboratory.

facturers, approximately 900 gins were equipped with lint-cleaning machinery during the 1951 ginning season. Estimating the average ginning volume of these plants at approximately 4,000 bales, 3,600,000 bales were handled through this machinery.

THE SAW PRINCIPLE OF LINT CLEANING FOR USE AT GINS

United States patent records disclose that as long ago as October 5, 1858, attempts were being made to perfect desirable lint-cleaning machinery for use in cotton gins. The staff of the U. S. Cotton Ginning Laboratory has long advocated research in this field. As early as 1939 the laboratory included in its program some experiments with devices that would clean lint at the gin. Various principles of lint cleaning were investigated, including redesigned mill-type beaters, flotation chambers, air-wash systems, double-process gins, and the regin principle. Extensive laboratory tests indicated that flotation

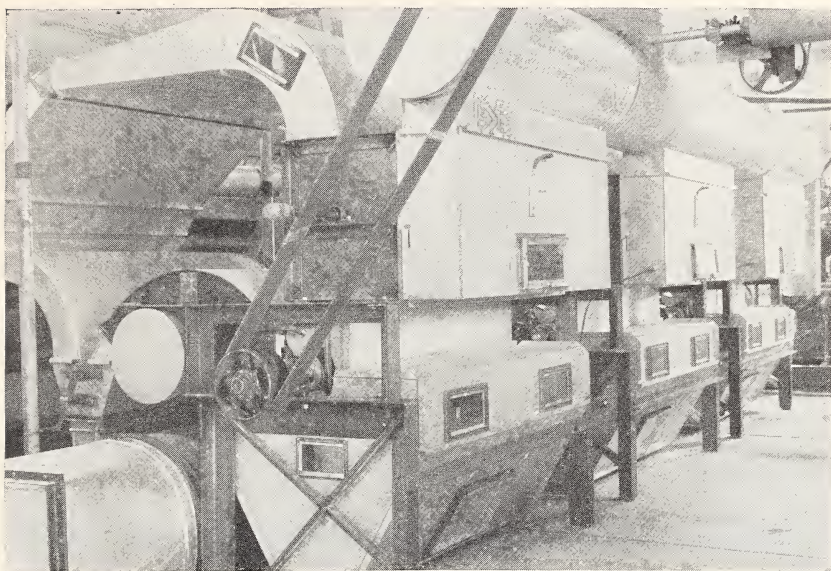


FIGURE 18.—Experimental lint cleaners, designed by the U. S. Cotton Ginning Laboratory, installed in 3-stand laboratory gin.

chambers and air-wash systems were ineffective, but that the use of the regin, the vertical-transfer cleaner, and the beater cleaner helped to facilitate trash removal. A full report on these experimental machines is given in previous publications.⁵

Of all the devices tested, the vertical-transfer cleaner more nearly approached in performance and principle the machine that the engineers and technologists of the laboratory were making an effort to develop. This device utilized a combination of centrifugal force, air wash, mechanical scrubbing and combing action, and gravity. In order to utilize all these actions, the laboratory designed a saw-cylinder lint cleaner that uses a single saw-cylinder (fig. 17). The newly designed cleaner was subjected to comprehensive laboratory tests during the 1947 season to determine the best saw speeds, grid bar design, air pressures, and other factors that would insure maximum cleaning with a minimum of fiber damage. With results obtained from these tests as a basis, three of these units were constructed, installed in the experimental laboratory gin, and subjected to tests during the 1948-49 ginning season (fig. 18). One section of this publication gives the results of these and subsequent field tests of lint cleaners. It shows that this method of cleaning has been accepted by the ginning industry and that gin manufacturers have either developed their own cleaners or have made adaptations of the lint cleaner designed by the U. S. Cotton Ginning Laboratory (figs. 19-21).

⁵ Stedronsky, Victor L., and Shaw, Charles S. The Flow-Through Lint-Cleaner. U. S. Department of Agriculture Cir. No. 858. November 1950; Gerdes, Francis L. "Cotton Lint Cleaning at Gins—An Evaluation From the Standpoint of Cotton Quality and Economic Factors." PMA, U. S. Department of Agriculture. May 1951.

FIGURES 19, 20, and 21 are commercial types of lint cleaners.

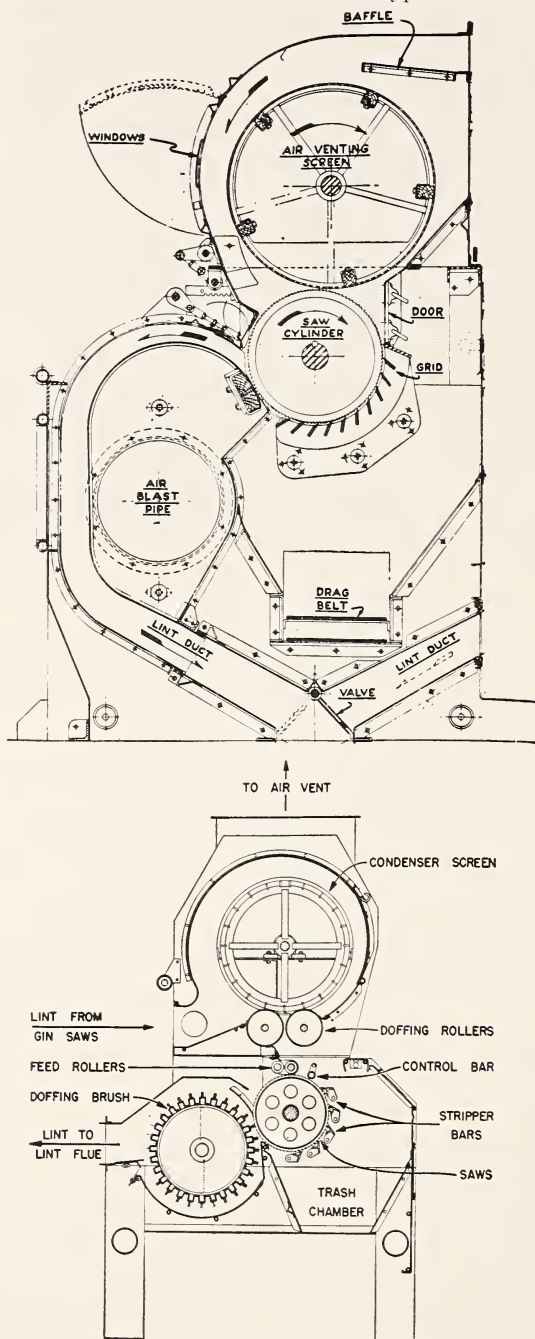


FIGURE 19.

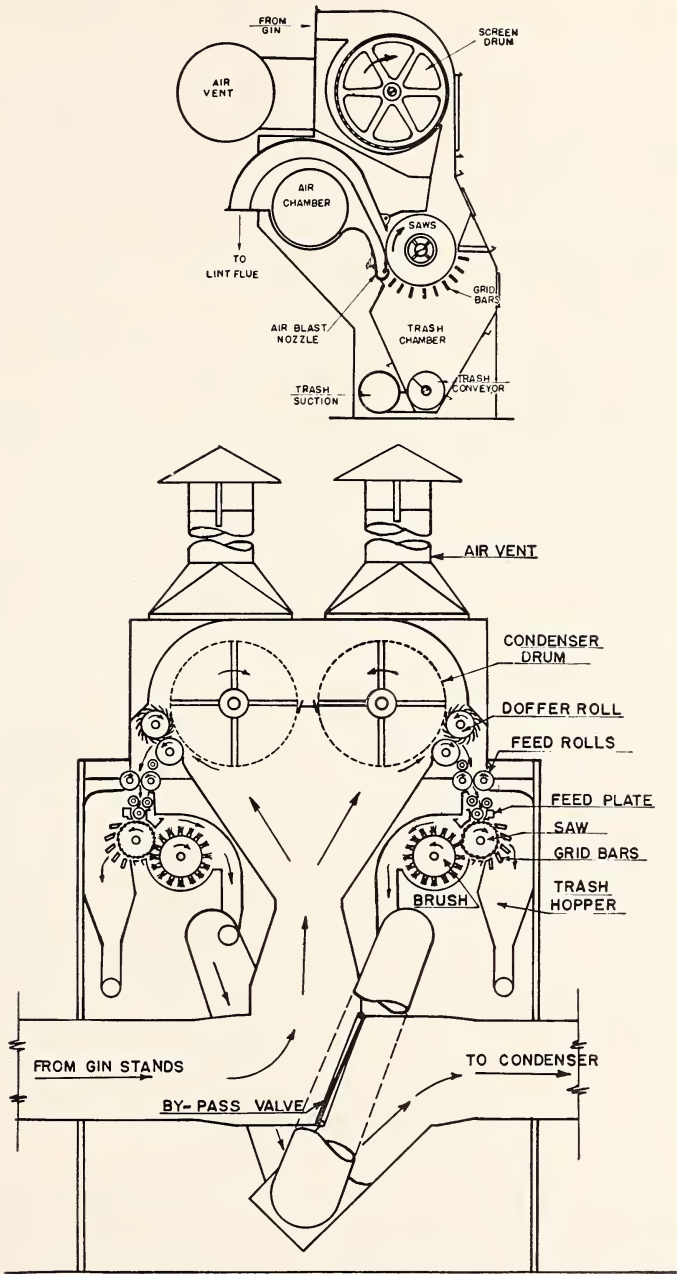


FIGURE 20.

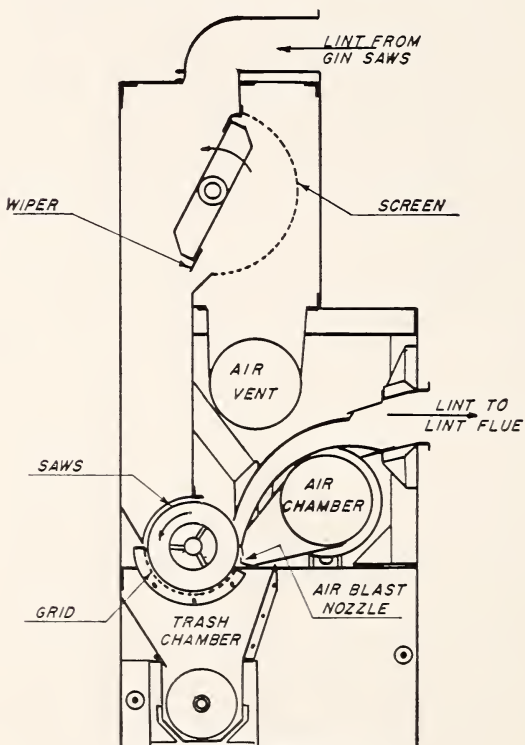
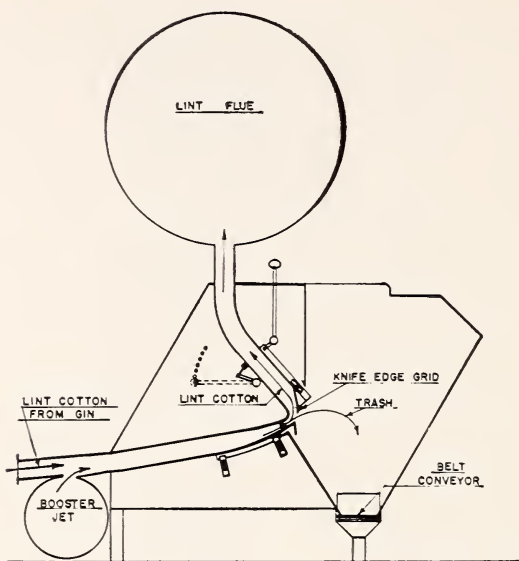


FIGURE 21.

REQUIREMENTS TO BE MET BY LINT CLEANERS AT GINS

In order to be practical and to have widespread use by the cotton ginning industry, lint cleaners must be sound from an engineering and technological standpoint. They must be capable of continuous use in ginning systems and of improving the grade of cotton without causing any harmful effects on the fiber and spinning quality. In addition, the net bale value derived from the use of lint cleaners must be sufficient to justify the investment and operating costs of such equipment.

FEASIBILITY FROM AN ENGINEERING STANDPOINT OF CONTINUOUS USE AS A PART OF THE CONVENTIONAL GINNING PROCESS

In designing and developing a lint cleaner, members of the ginning laboratory staff kept in mind that it must be feasible from an engineering standpoint and that it must provide: (1) Processes and equipment for cleaning lint cotton between the gin stands and the baling press; (2) a process and apparatus of relatively simple construction without the intricate details and expensive shop work of a more complex machine; (3) a satisfactory method of introducing and delivering the fibers to the lint cleaners, in substantially the same individual form as received from the gin stands, with a continuous flow of the air stream; (4) a cleaning unit with capacity sufficient to handle adequately the variable quantities of lint fiber that are normally delivered from a full-size cotton gin stand without retarding ginning processes; (5) a trash chamber to receive and dispose of the trash and waste removed from the fiber by the cleaner; and (6) a satisfactory means of doffing the cleaned fibers from the cleaning apparatus to effect a continuous unrestricted flow of the cotton from the gins to the baling press.

Consideration has been given also to mechanical and installation features that permit the adaptation of lint cleaners to both old and new ginning plants without submerged lint flues. In either instance, however, the necessary space for installation must be available and sufficient power must be provided. From 5 to 10 additional horsepower are required for each lint cleaner unit. This added power provides for the operation of the lint cleaners as well as for the additional air-blast doffing fan, trash fan, or conveyor.

FEASIBILITY OF IMPROVING GRADE WITHOUT HARMFUL EFFECTS ON OTHER QUALITY FACTORS

Based on proving-ground operations, good results were obtained with the lint cleaners from the standpoint of both engineering and technological performance. No serious operating difficulties were experienced, and the test runs proved that the cleaners have the capacity and endurance for constant use in handling the full lint delivery from cotton gins.⁶

⁶ See footnote 5.

The staple length of the cottons used in the proving-ground tests ranged from $1\frac{1}{16}$ inch to $1\frac{3}{32}$ inches, and average grades ranged from Strict Middling plus on early hand-picked cottons down to Strict Good Ordinary minus on late-exposed machine harvestings.

The average grades of the early season machine-picked cottons ranged from Low Middling, when a moderate seed cotton cleaning process was followed, up to Strict Low Middling when the elaborate seed cotton cleaning process was used and the cotton was also put through the lint cleaners. On the late-exposed machine-picked cotton, grades averaged Strict Good Ordinary minus when it was cleaned by the moderate cleaning setup and was not put through the lint cleaner; whereas an average grade of Low Middling minus was obtained from the very elaborate cleaning process which included cleaning the lint. The grades obtained in processing machine-picked cotton by the various seed cotton cleaning combinations, including lint cleaning, averaged about two-thirds of a grade higher in each instance than when it was cleaned by the same machinery combinations and the lint was not cleaned. Best all-round grade improvements were obtained on machine-picked cotton when the elaborate seed cotton cleaning process, including lint cleaning, was followed.

The grades of the hand-harvested cotton ranged from Strict Middling on the early season hand-picked cottons down to Strict Good Ordinary plus on the late-exposed hand-snapped cottons, and the improvement resulting from lint cleaning ranged from one-third to two-thirds of a grade.

In all the tests with the various types of cottons and machinery combinations, the staple length of the cotton was not affected by the lint cleaning process. Despite the strong mechanical force and the heavy friction involved in processing cotton through the gin stand, fiber length tests showed that the average loss in the staple length of the mechanically ginned lint was only $\frac{1}{32}$ inch, as compared with the hand-pulled fibers. The action of the lint cleaning saws is very gentle as compared with the relatively harsh and forceful pulling action of the gin saws in contact with gin seed rolls and in passing through narrow rib spaces. Fibers are received and released from the saws of the flow-through lint cleaners in substantially the same form as they are delivered from the gin stands.

The average grade improvement obtained by using the lint cleaners on the machine-picked and rough-harvested cottons as compared with clean hand-picked cottons indicates the greater cleaning potential of the lint cleaners on the trashier cottons. This is further borne out by the fact that there is an increase in the weight per bale of waste removed by the lint cleaners which accompanies increases in the foreign matter content of the seed cotton. Likewise, there is a consistent decrease in the weight of lint cleaner waste accompanying increases in the intensity of seed cotton cleaning.

On a bale basis the weight of lint cleaner trash is small compared with the weight of trash removed by the seed cotton cleaning equipment. The lint cleaner trash, however, is very significant when it is considered that the waste is composed principally of small leaf particles pepper trash, dirt, motes, and short irregular fibers that would lower the grades if left in the cotton (fig. 22).

The average weight of waste removed by the lint cleaners used in the tests ranged from 3.5 pounds on the clean hand-picked cottons to as much as 11.0 pounds per bale on late-season trashy cottons. Based on Shirley Analyzer tests, the samples of lint cleaner waste representing all types of harvesting contained an average of 82 percent actual trash and 18 percent short irregular fibers such as would normally be removed in cleaning processes at textile mills.



FIGURE 22.—Samples of waste removed from ginned lint by a lint cleaner. Left, waste removed by the cleaner; right, waste that has been separated to show the pin trash and motes and the short, irregular fibers. (Samples about one-sixth actual size.)

A further analysis of average quantities of lint cleaner waste and its components of trash and fiber associated with lint cotton of different grades shows that there is a progression in total lint cleaner waste ranging from 5.6 pounds per bale on Strict Middling cotton to 17.6 pounds per bale for Good Ordinary grades. The fiber loss was generally about the same, regardless of the grade of the cotton—from 1.6 to 2.2 pounds per bale for this range of grades.

As shown by spinning tests of representative samples taken in connection with the 1948 lint cleaning studies, the foreign matter removed by the flow-through lint cleaners at the gin was reflected in the lower amount of manufacturing waste obtained by the picker and carding processes. Yarn skein strength, yarn appearance, and the number of neps in the card web were not affected significantly by lint cleaning.

In addition to making evaluations of the quality of ginning in the laboratory gin equipped with lint cleaners, extensive field studies have been made on gins so equipped. Both the laboratory tests and the field studies proved that the lint cleaners greatly improve the grade of the lint without impairing other quality factors of the fibers. Tests

on 53 paired samples taken at the laboratory and in the field of cotton ginned with and without lint cleaning showed that lint cleaning gave an improvement of two-thirds of a grade from Middling to Strict Middling minus on cotton which, without lint cleaning, was Middling and better in grade. Lint in the Strict Low Middling grade range was improved one-third of a grade to Strict Low Middling plus as a result of lint cleaning. Likewise, grades ranging from Low Middling down were improved by lint cleaning from Low Middling minus to Low Middling, or one-third of a grade (table 4). Putting cotton through the lint cleaner caused no significant differences in yarn strength, yarn appearance, or nep count for any of the three grade ranges. Manufacturing waste was substantially reduced in each case because the lint cleaner removed short, irregular fibers with the trash. Tests showed that the cleaner removed about 2 pounds of short, irregular fibers per bale regardless of the foreign matter content of the cotton being cleaned. The amount of material removed by the cleaners depends on the quantity of foreign matter in the lint. This amount ranges from 7.1 pounds a bale for cottons of Middling and better in grade to 13 pounds for grades of Low Middling and below.

Lint cleaners have proved practical in laboratory and field tests. Many of them are being installed in place of some overhead seed cotton cleaning equipment in order to obtain higher grades of machine-picked and rough-harvested cottons without damaging fiber properties and without adversely affecting spinning quality. The lint cleaner is designed specifically for cleaning cotton in the lower grade ranges. Even though grade benefits are obtained on high-grade lint-cleaned cotton, there is no net monetary gain in bale value because of the weight loss resulting from lint cleaning (table 5). The monetary gain from lint cleaning depends on the price spread between various grades which, in turn, reflects the demand for certain types of cotton on the current market. During 1947 the use of lint cleaners on cotton that graded Middling and better resulted in a net bale value loss of 80 cents. But premiums were such that benefits were realized on the higher grades for the crop years 1948 through 1951 inclusive. On grades from Low Middling down, the lint cleaner gave substantial grade benefits from 1947 through 1949.

Laboratory tests showed that cotton put through an optimum amount of seed cotton cleaning machinery and then through a lint cleaner will yield higher grades than cotton put through an excessive amount of cleaning machinery and that the spinning quality of the lint will be preserved (table 6). The relatively harsh action of an excessive amount of seed cotton cleaning machinery on cotton resulted in a higher nep count, a lower yarn strength, and a lower yarn appearance, than was the case when an optimum amount of seed cotton cleaning equipment was used and the cotton was also put through a lint cleaner.

TABLE 4.—Effect of seed cotton and lint cleaning on foreign matter and moisture content, lint cleaner waste, classification, fiber properties, manufacturing performance, and carded yarn quality results on hand- and machine-picked cottons, crops 1946-49¹

Item	Grade							
	Middling and better		Strict Low		Middling		Low Middling and below	
	Without lint cleaning		Without lint cleaning		With lint cleaning		Without lint cleaning	
	With lint cleaning	Without lint cleaning	With lint cleaning	Without lint cleaning	With lint cleaning	Without lint cleaning	With lint cleaning	Average
Foreign matter content:								
Wagon sample-----percent-----	4.9	4.9	12.7	12.7	12.7	27.0	27.0	17.5
Lint-----do-----	4.0	2.9	5.5	4.2	4.2	9.5	7.7	5.5
Foreign matter removed by lint cleaner pounds-----		7.1		8.4			13.0	10.3
Moisture content:								
Wagon sample-----percent-----	9.2	9.2	11.3	11.3	11.3	12.0	12.0	11.2
Lint-----do-----	5.2	5.3	5.4	5.3	5.3	6.5	6.0	5.7
Classification:								
Grade, index-----	99.5	102.2	93.2	96.2	96.2	80.8	84.8	92.3
Designation-----	M	SM-	SLM	SLM+	SLM+	LM-	LM	SLM-
Staple length (1/32 inch)-----	34.5	34.5	33.5	33.5	33.5	32.7	32.8	33.4
Fiber data:								
Length (Fibrograph):								
Upper half mean-----inches-----	1.07	1.07	1.04	1.03	1.03	1.00	1.00	1.02
Uniformity ratio, index-----	77	77	78	77	77	76	76	77
Fiber tensile strength:								
1,000 pounds per square inch-----	83	82	79	79	79	77	77	79
Spinning data:								
Picker and card waste-----percent-----	8.9	7.9	10.1	9.0	9.0	13.7	12.2	10.2
Neps per 100 square inches of card web-----	34	37	30	34	34	27	26	31
Yarn skein strength:								
22s-----pounds-----	118	118	108	108	108	104	105	109
36s-----do-----	65	65	60	60	60	56	56	59
60s-----do-----	32	33	30	30	30	29	29	30
Yarn appearance, index ² -----	97	95	98	97	97	90	89	93

¹ Data represent 53 paired samples.² Index represents average appearance of all counts spun; an index of 90 is used for grade C, and 70 for grade D.

TABLE 5.—*Effect of lint cleaning on bale value for specified grade ranges, crop years 1947-51*

Crop year	Lint cleaning	Bale value for specified grade ranges ¹		
		Middling and better	Strict Low Middling	Low Middling and below
		<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>
1947----	Without-----	184. 65	174. 95	136. 05
	With-----	183. 85	176. 24	144. 40
1948----	Without-----	167. 05	154. 65	122. 55
	With-----	167. 78	157. 51	126. 91
1949----	Without-----	166. 70	149. 05	127. 90
	With-----	169. 21	153. 92	130. 27
1950----	Without-----	219. 15	204. 15	192. 65
	With-----	220. 03	206. 32	191. 20
1951----	Without-----	210. 45	199. 20	178. 05
	With-----	210. 86	200. 38	178. 88

¹ Bale value calculations based on a bale weight of 500 pounds without lint cleaning and average prices received on the Memphis, Tenn., market, by years.

TABLE 6.—*Comparative classification, manufacturing performance, and carded yarn results on cotton cleaned by an optimum seed cotton cleaning setup plus lint cleaners and a seed cotton cleaning setup having an excess of cleaning units ¹*

Item	Optimum seed cotton cleaning and lint cleaning ²	Excessive seed cotton cleaning ²
Grade:		
Index-----	91. 3	89. 4
Designation-----	SLM—	LM+
Staple length----- (½ ₃₂ inch)-----	33. 7	33. 6
Foreign matter content of lint----- percent-----	5. 8	6. 1
Picker and card waste----- do-----	10. 4	11. 2
Neps per 100 sq. in. of card web-----	30	37
Yarn skein strength:		
22s----- pounds-----	110	107
36s----- do-----	59	58
Yarn appearance, index ³ -----	94	91

¹ Classification and spinning data represent averages for 9 paired samples.

² Excessive seed cotton cleaning setups had 1 more overhead bur machine and the equivalent of 2 more overhead cylinder cleaners, or 1 more drier and the equivalent of 2 more overhead cylinder cleaners as compared with the optimum seed cotton cleaning setups operating in connection with lint cleaners.

³ Index represents average appearance of all numbers spun; an index of 110 is used for grade B; 90, for grade C; and 70, for grade D.

An examination of these and numerous other test data showed that fiber tensile strength is virtually unaffected by excessive cleaning or by malpractices in gin operation which affect materially other fiber properties. Fiber tensile strength is considered by mills as an important single factor in selecting cottons to meet specific requirements. It also serves as a guide, together with staple length, in predicting yarn strength. Tensile strength is determined primarily by the variety of the cotton and weather and growth conditions, and not by the treatment received by the seed cotton or lint in the ginning process, except when extremely high temperatures are used for drying.

FEASIBILITY FROM AN ECONOMIC STANDPOINT

To be practical from an economic standpoint, lint cleaners must give sufficient net bale value improvement to justify their purchase and operation.

A study to determine the cost and quality of ginning at gins equipped with lint cleaners, as compared with plants not so equipped, was made in the Yazoo-Mississippi Delta in 1949.⁷ It was found that gins equipped with lint cleaners had an average volume of 3,409 bales as compared with 2,950 bales for gins not offering this service. The increased volume made the total per bale operating cost lower for the lint-cleaner-equipped plants. Plants that had a greater machinery replacement value than about \$20,000 because they were lint-cleaner equipped, had slightly higher fixed costs and higher charges for depreciation and interest than plants not so equipped. The man-hour requirements per bale for the two groups of gins were identical but the fuel requirements for lint-cleaner-equipped plants were higher because of the type of fuel used.

Lint cleaners require approximately 5 to 10 horsepower per unit to operate. The little additional fuel required for the operation of this machinery, therefore, is not significant when it is compared with the fuel required to operate the additional driers that would be necessary to obtain better grades at gins not equipped with lint cleaners. Formerly the general practice followed by gins not having lint cleaners was to use more drying processes at higher air-drying temperatures than the lint-cleaner-equipped plants. Since the consumption of drier fuel was approximately only 2 gallons of artificial gas per bale, the expense involved in supplying power for lint cleaners assumes less importance even though some of these cost factors may tend to increase total cost of operation of lint-cleaner-equipped plants from 50 to 75 cents a bale.

Gins equipped with lint cleaners received \$1.55 a bale more in gin tolls than did gins not using this equipment. However, this differential that conventionally equipped plants received was offset by the sum of 25 cents for bagging and ties; hence \$1.55 minus 25 cents, or \$1.30, represents the net advantage in ginning revenue a bale for lint-cleaner-equipped plants. When operating at their respective volumes, gins without lint cleaners managed to "break even" on

⁷ Gerdes, Francis L. Cotton Lint Cleaning at Gins—An Evaluation from the Standpoint of Cotton Quality and Economic Factors. PMA, U. S. Dept. Agr. May 1951.

ginning revenue alone, whereas gins using lint cleaners showed a profit of \$1.29 a bale.

In one season, lint cleaners included in a test removed, on the average, 6.8 pounds of foreign material per bale from hand-picked cotton, and 11.6 pounds from machine-picked cotton; however, some weight loss resulted from the practice followed by gins not using lint cleaners of employing higher air-drying temperatures. Although it is generally conceded by the ginning industry that the use of such temperatures is helpful in effectively removing foreign matter, it is also true that they remove excessive amounts of moisture from lint. For lint as it leaves the gin stands, the higher drying temperature used by gins not equipped with lint cleaners gave higher grades than did lint-cleaner-equipped plants when comparable seed cotton and overhead machinery was used. This was due to the extra moisture and foreign matter removal made possible by the higher temperature.

An average seasonal increase in value of \$3.91 a bale was obtained on lint-cleaner-equipped gins on hand-picked cotton, when quality improvements were considered and when adjustment was made for the loss in weight incurred by the use of lint cleaners. During the early part of the season, however, when the grades normally obtained were Middling or better, the loss in weight resulting from the use of these cleaners and the narrow premiums received for the higher grade ranges, resulted in value benefits of less than \$1 a bale. Grade improvements on machine-picked cotton in lint-cleaner-equipped gins amounted to one-third of a grade in the Low Middling range and gave an increased value of \$3.25 a bale, after quality benefits and weight losses had been taken into consideration.

The seasonal bale value advantage of cotton ginned in plants equipped with lint cleaners, over cotton ginned in plants not equipped with cleaners, amounted to \$2.50 on hand-picked and \$3.31 on machine-picked cotton. Bale benefits on the lint-cleaner-equipped gins as a group ranged from approximately \$4 to \$6 on late-picked cotton. After making adjustments for added ginning fees charged by gins equipped with lint cleaners, the net bale value benefits to producers amounted to approximately \$1.25 for hand-picked cotton and \$2 for machine-picked cotton.

OPERATING PRACTICES FOR EFFECTIVE CLEANING OF LINT AND THE PRESERVATION OF FIBER QUALITY

The ginning industry is agreed that the lint cleaner is effective in cleaning rough hand- and machine-harvested cottons. Like any other gin equipment, it must be operated in accordance with the manufacturer's recommendations if it is to give the necessary grade benefits and preserve the spinning quality of the cotton.

SEED-ROLL DENSITY AND RATES OF FEEDING

In order to avoid discounts resulting from rough preparation, the cotton must be relatively dry and the gin stand must be operated with a loose seed roll. Loose roll operation is also essential for the preservation of other quality factors which are not measured in terms

of grade and staple but are reflected in the spinning performance of the lint. Fast feeding, which results in tight seed rolls, is also reflected in the operation and effectiveness of the lint cleaner.

Tests conducted on three types of lint-cleaner-equipped gins in the Mississippi Delta in 1949 indicated the importance of operating the gin stands with moderate rates of feeding and with loose seed rolls in order to keep within the capacity for which the lint cleaners were designed. It was found that the cleaning effectiveness of the gin stands and lint cleaners was reduced and the neps in the card web increased from an average of 53 to 70 as a result of fast feeding (table 7). The amount of lint cleaner waste increased slightly with the faster rate of feeding but no additional grade improvement resulted from this rate. It was noted that a normal rate of feeding without lint cleaning and a fast rate of feeding with lint cleaning produced the same grade, Strict Low Middling. From a grade standpoint, a fast rate of feeding nullified the effectiveness of the lint cleaners completely. The fast rate of feeding, whether used with or without lint cleaners, caused consistent and significant reductions in yarn strength and corresponding reductions in yarn appearance grade.

TABLE 7.—*Effects of three commercial lint cleaners on the classification, manufacturing performance, and carded yarn quality of late-season, machine-picked cotton, ginned at varying rates of feed, crop of 1949*¹

Item	Normal rate of feed		Fast rate of feed	
	Without lint cleaning	Saw cylinder lint cleaning	Without lint cleaning	Saw cylinder lint cleaning
Grade:				
Index-----	94.4	96.1	90.2	92.8
Designation-----	SLM	SLM+	SLM—	SLM
Staple length ($\frac{1}{32}$ inch)-----	33.8	33.7	33.8	33.8
Lint cleaner waste per bale				
pounds-----		6.8		7.2
Foreign matter content of lint				
percent-----	5.5	4.0	6.2	4.9
Picker and card waste-----do-----	11.1	9.5	12.0	10.8
Neps per 100 square inches of card web-----	49	53	56	70
Yarn skein strength:				
22s-----pounds-----	102	104	99	98
36s-----do-----	58	59	56	56
50s-----do-----	35	35	34	34
Yarn appearance, index ² -----	99	99	95	94

¹ Classification represents averages of 4 samples ginned on each of 3 gins having lint cleaners, and spinning tests represent 2 composite samples ginned on each of the 3 gins equipped with lint cleaners.

² Index represents average appearance of all numbers spun; an index of 110 is used for grade B; 90, for grade C; and 70, for grade D.

CONDENSER OPERATING PRACTICES

All saw-cylinder type lint cleaners contain a screened vent ahead of the cleaning saws to bleed off air conveying the lint cotton from the gin stand. The amount of air to be separated from the lint prior to cleaning varies from 50 to 100 percent for different designs of lint cleaners. In any case, the manufacturer's recommendation for balancing the air pressure in the cleaner should be followed closely, as the amount of air passing through the saw cylinder and trash chamber will influence its cleaning effectiveness and smoothness of operation.

In lint cleaners using an air-blast doffing system, it is important that the doffing pressure of the gin stand be kept low, consistent with good operation, in order to hold operating power requirements to a minimum, reduce the amount of air to be handled by the lint-cleaner condenser, and reduce the possibility of backlash. With the adequate drying systems now employed in modern gins, it has been found that lower nozzle pressures may be used more effectively for doffing than was the case a few years ago. The lint-cleaner nozzle pressure should be adequate to convey the cleaned fiber to the condenser and press.

CARE AND MAINTENANCE OF LINT CLEANERS

The lint cleaner, like other machines, must have proper care and maintenance to insure efficient operation. When lint cleaners are installed, particular attention should be given to the lint flues leading from the gin stand to the cleaner to be certain that all inside surfaces are smooth—that no rough edges of metal or bolt heads project into the flue to cause tags of cotton to accumulate. The bypass valves of the lint cleaner should also be inspected carefully for rough edges and faults preventing complete closure. The gin flues should be examined frequently for several days after being placed in operation to determine whether there is any lint accumulation or any rough spots which may have been overlooked during installation. Should any tags of cotton be found, steps should be taken to eliminate the rough spots causing them. These lint accumulations, if allowed to increase, will reach sufficient size to damage seriously the saws and grid bars when they break loose and enter the cleaner.

The lint-cleaner condenser and air-vent flues should be cleaned regularly each day to insure against chokeage. Proper maintenance of condenser doffing rollers is necessary to insure satisfactory operation of lint cleaners so equipped. The rollers should be kept in adjustment and the flashings replaced when they become worn sufficiently to lose their effectiveness as an air seal. Air blowing by the doffing roller will disturb the bat of cotton entering the feed rollers; this disturbance of the bat will cause chokages at the feed rollers and the loss of usable fiber with the lint cleaner trash.

The speed of the condenser is set by the manufacturer and should not be changed. In some cases, departure from this speed will affect the operation of the lint cleaner materially. The condenser should be inspected to ascertain whether the surface is smooth enough to eliminate the possibility of lint accumulations on rough spots.

The lint-cleaner saws should be checked and cleaned at least once each day to remove sticks, stems, or other extraneous matter impaled on the saw teeth. The saws should be kept sharp and in good operating condition. Experience has shown that the necessity for sharpening lint-cleaner saws depends upon the type of cotton handled.

Grid bars and air-blast nozzles should be inspected regularly for alinement and to see that they have proper clearance. In the case of lint cleaners that utilize a brush instead of an air-blast doffing system, the brush should have the same care and maintenance as is given to a gin-stand brush. For proper doffing, the brush should mesh with the saw to the depth of the saw tooth.

The trash-disposal units of the cleaner should receive periodic attention. Conveyor belts should be kept tight and dropper wheels should be inspected for damage and wear. Glass inspection doors that are cracked or broken should be replaced to prevent disturbance of proper air movement and balance in the cleaner.

FACTORS IN PLANNING AND EQUIPPING GINS TO HANDLE MECHANICALLY HARVESTED AND ROUGHLY PICKED COTTON

Ginning facilities have been changing rapidly in some areas in recent years as ginners have made an effort to keep pace with current harvesting practices. Controlled ginning charges, the relatively low revenue derived from ginning, and the increased machinery costs are among the factors that have caused many ginners to proceed with caution in building new plants or modernizing existing ones, and in trying to cope with the problems involved in handling cotton of high-foreign-matter content. Some ginners, on the other hand, have acted hastily and have installed equipment that was not justified by local conditions. A typical arrangement of equipment in a modern gin for handling cotton of high-moisture and foreign-matter content is shown in figure 23.

The potential volume to be expected and the local trend in harvesting practices are the two main items to consider when planning to erect or modernize plants. Other items to consider are the selection of equipment to specific needs, and the selection and training of management and personnel to operate the gin in an efficient manner.

The volume required for a gin to "break even" depends, of course, on operating costs, ginning charges, wrapping charges, interest on investment, and several other factors. Field studies and observations in widely scattered areas throughout the Cotton Belt have shown that the "break-even" point for gins equipped with varying amounts of machinery will range generally from elaborately equipped gins that handle from 2,500 to 3,000 bales; gins containing a moderate amount of machinery that handle from 1,500 to 2,000 bales; and gins with a minimum of equipment that handle from 800 to 1,200 bales. The minimum-equipment types include those equipped with extractor-feeders and little or no drying. Elaborate cleaning facilities should not be installed unless they are warranted by rough harvesting conditions.

As already pointed out, no plant should contain more than 20 to 24 cylinders of cleaning, in combination with overhead bur-extracting equipment, an adequate drying system, and large extractor-feeders, or the equivalent in screening and extracting equipment. Cleaning beyond the extent possible in a plant of this type will result in reductions in fiber quality and excessive machinery and operating costs. When cleaning in addition to the minimum area requirements discussed on page 12 is required, it is wise for ginner to consider the use of lint cleaners rather than to add more elaborate seed cotton cleaning equipment. It has been found that lint cleaners give the best returns for money spent for cleaning equipment above basic area requirements and cost slightly more than one dollar a bale for depreciation and operating expenses at a volume of 3,000 bales.⁸

Efficient management can turn a losing plant into a profitable one in many instances. Good management will be reflected in properly ginned cotton, which means satisfied customers and lower operating costs. The importance management plays in the modern gin cannot be overemphasized.

PROBABLE FUTURE PATTERN OF THE GINNING INDUSTRY

The need for development and improvement of the tools used in mechanized cotton production is recognized by all segments of the industry. The gin-cleaning equipment available for the handling of mechanically harvested cottons which, up to the present time, have had a relatively high content of foreign matter, has proved to be feasible and practical. There was a difference of from two to three grades between hand- and machine-picked cotton when the cotton picker first came into commercial use. Through improved field practices and better gin-cleaning machinery these differences have been narrowed to a one-grade difference over a period of relatively few years. Thus far the progress made in developing machinery to be used in producing and processing cotton is very gratifying, but even greater advances must be made to bring about a more successful and profitable mechanization of the cotton industry.

The close cooperation of specialists in many fields must be enlisted in solving the problems involved in mechanizing cotton production. These include (1) breeders, to develop cottons adapted to mechanical production and with inherent characteristics that permit easy removal of the foreign matter from the cotton by the gin- and mill-cleaning equipment; (2) engineers and agronomists, to refine present methods and to devise new methods of mechanical production and harvesting; (3) chemists, to discover and perfect weed-control chemicals and defoliant that will be effective under all climatic conditions encountered in the Cotton Belt; and (4) engineers, technologists, and economists, employed by gin manufacturers and ginning laboratories to find and perfect more effective methods of cleaning and ginning that will preserve the inherent spinning qualities of cotton in the most economical manner possible, from the standpoint of both producers and ginner.

⁸ See footnote 7.

Until recently the gin was considered to be the limiting factor in a mechanized cotton-harvesting program. With this in mind, ginnermen equipped their plants with large amounts of overhead cleaning and extracting equipment in an effort to clean the trashy cottons sufficiently to make mechanical harvesting practical from an economic standpoint. The fiber damage that occurs from the actions of excessive machinery and overdrying results in reductions in the quality of yarns spun from machine-picked cottons. This trend has been changed as a result of the adoption of better ginning practices and of a reduction in plants of excessive amounts of overhead cleaning equipment through the use of lint cleaners. By using a balanced cleaning system ahead of and behind the gin stand, and adequate drying equipment, the ginner obtains higher grades without detrimental effects on fiber quality.

The use of mechanical harvesting methods enables the farmer to harvest a crop much more rapidly than with hand labor; as a result, the ginner is faced with two alternatives—storage facilities must be provided or additional gin stands installed to keep pace with the accelerated rate of harvesting. The method which the ginner should employ will depend on local conditions. Many gins that normally operate only one shift will be able to meet economically the increased demand for service by adding an extra shift and operating longer hours during the congested period.

The trend toward larger, more centrally located plants has been accentuated during the last few years, because a large volume of ginning is necessary in order to make a modern, well-equipped plant a profitable enterprise. These modern gins must be conveniently located on all-weather roads to accommodate large trucks and multi-bale trailers which are used for hauling cotton in most sections of the Cotton Belt. Large volumes are also necessary in order to provide the services expected by farmers such as handling trailers on the gin yard, shipping bales to the compress or warehouse, and sampling bales—services that require additional personnel. The sampling of cotton should be simplified by the use of an automatic sampling unit which may be installed as a part of the gin equipment in order to obtain a sample of the bale of cotton more representative than is now being obtained in the conventional manner.⁹

NEED FOR CONTINUED SEARCH FOR NEW AND MORE EFFICIENT MEANS OF HANDLING, CLEANING, AND GINNING COTTON

The many machines that have been developed for cleaning cotton are constantly being improved. Also, much information is available to ginnermen that will aid them in improving their ginning services and efficiencies. However, there is a need for continued study of ginning problems, in an effort to develop further improvements in the cotton ginning processes.

⁹ Larrison, John E., and Gaus, George E. Automatic Mechanical Equipment for Sampling Cotton Bales During Ginning. PMA, U. S. Dept. Agr. 22 pp., illus. March 1951.

The development of devices that will control various functions and processes in the gin and will adapt their operation to the particular condition of the seed cotton received from time to time, is of paramount importance. The processes which should be controlled include drying or conditioning, cleaning, extracting, and packaging.

Proper conditioning of the seed cotton is necessary to insure effective cleaning. Seed cotton that is not dried sufficiently will not give up trash readily. On the other hand, overdrying results in fiber damage and excessive losses in bale weight. Cottons harvested in arid regions may require the addition of moisture to condition them for cleaning or ginning in such a way as to preserve their inherent fiber properties. Thus, controls that will insure proper operation of the conditioning equipment are needed.

An even flow of seed cotton through the conditioning and cleaning machinery is necessary to maintain efficient operation of the gin. Large "slugs" of seed cotton entering the machines reduce the cleaning efficiency of the equipment and cause chokages and breakdowns. For best results cotton should be fed through the machinery at the same rate at which it enters the gin stands, the amount of overflow being kept to a minimum.

These are only a few of the pressing problems for which solutions are necessary in order to improve the effectiveness of gins under existing conditions. As a result of changes in operating and harvesting practices, as well as in cotton characteristics and other conditions, new problems are always arising which affect the various ginning processes and necessitate constant research.

SUMMARY AND CONCLUSIONS

Cleaning machinery for use in cotton gins was developed as rough-harvesting practices made it necessary to devise means to aid in removing foreign matter and thus preserve the quality of the lint at gins. The major developments in cleaning equipment—the spiked drum, the spider arm, and paddle-wheel cylinders operating over some type of screen, saw-cylinder cleaners and extractors, and combinations of these various types—have taken place within the last 50 years. Although unchanged in principle, these cleaning machines have been refined to reduce damage to the seed cotton. The extent to which the machines are used depends to a considerable degree on the varieties of cotton raised and the harvesting practices prevalent in a particular area. The conditioning of seed cotton before it is cleaned, made possible by the development of the cotton drier, enables the ginner to subject the cotton to more cleaning machinery than was previously possible without causing fiber damage. Almost one-half of the active gins in the Cotton Belt are now equipped with one or more driers. The proportion of gins so equipped varies from about one-fourth in the Southeastern States to more than two-thirds in the Far West. The use of overhead cleaning equipment, as in the case of cotton driers, increases from the eastern to the western part of the Cotton Belt.

In the Southeastern States the investment in gin cleaning and conditioning equipment has increased from less than 20 percent of the total cost of a plant 10 years ago to one-third or more at the

present time. The cost of cleaning and conditioning equipment for gins in the Mississippi Valley and the western part of the Cotton Belt represents about 50 percent of the total investment. To house this additional equipment it has been necessary to make gin buildings 50 percent larger. The size of plants in these sections of the Belt now approach or equal the size of the plants in west Texas and western Oklahoma where rough-harvesting methods have been used for a number of years. The additional investments in this area have been mostly for conditioning equipment.

Despite improved cleaning equipment, the quantity of low-grade cotton has increased rather steadily. Most of this increase in low grade is the result of rough harvesting practices but some of it may be attributed to the breeding of early maturing, longer staple, finer fibered varieties of cotton. The breeding of cottons that are adapted to mechanical and rough-harvesting methods and the use of new methods of cleaning will do much to preserve the quality of the crop.

The moisture content in machine-picked cotton will range from 2 to 5 percent higher than in hand-picked cotton. Also, the type and amount of foreign matter vary considerably with different methods of harvesting. The amount of foreign matter in seed cotton will range from 15 to 40 pounds per bale for relatively clean hand-picked cotton and from 800 to 1,200 pounds for machine-stripped cottons. The extraneous material in hand-picked cotton consists primarily of leaf trash with a few burs, whereas machine-stripped cotton contains a preponderance of stems, sticks, burs, bolls, and leaf. After cleaning and ginning, the lint from bales of hand-picked cotton will contain from 10 to 20 pounds and from bales of machine-picked cotton, 30 to 60 pounds of foreign material. The amount and type of conditioning and cleaning equipment needed in gins in various sections of the Cotton Belt depend to a large degree on the harvesting practices followed and the variations in soils and climatic conditions in these sections. To guide ginners in determining basic gin needs, the Cotton Belt has been divided into six areas. In addition to extractor-feeders and huller-front gin stands, the amount of equipment necessary to meet minimum requirements will range from a small amount of drying equipment and a cylinder cleaner or the equivalent in some sections of the Belt, to as much as a full tower drier, a full-size bur machine, and 14 cylinders of cleaning or their equivalent.

Laboratory tests indicate that a total of 24 cylinders of cleaning in combinations with adequate bur-extracting equipment or the equivalent is the maximum amount of seed cotton cleaning machinery that may be used on rough-harvested cottons without causing excessive fiber damage. Grade differences averaging approximately one-third of a grade may be expected between various combinations of this elaborate ginning setup and very simple setups. Furthermore, it was found that the proper sequence of a cleaning combination consists of drying, cleaning, extracting, and cleaning. This sequence insures maximum effectiveness from the machinery used. In west Texas and western Oklahoma, where large quantities of sand are present in the cotton, an air-line cleaner is used ahead of the drier to remove much of the sand and assist in breaking bolls open to extract the lint.

Proper conditioning is essential to obtain maximum cleaning. In

general, the greater the moisture removal through drying, the higher is the grade of cotton. Fiber laboratory tests showed that there were slight but consistent, reductions in fiber length and strength at progressively higher drier temperatures when the single-stage or chain-drying was used. These results are confirmed by spinning test data which indicate that drying aided in reducing manufacturing waste, whereas excessive drying tended to lower yarn strength and appearance grade. Although higher temperatures may be used successfully on very damp cottons, drying air temperatures of 220° F. measured at the inlet of the drier appeared to give best over-all results in single-stage driers.

Because of the limits encountered in cleaning seed cotton with existing machines and because of the desirability of cleaning trashy cottons further in order to make rough-harvesting practices economically feasible, a lint cleaner was developed. Numerous methods and devices for cleaning, such as redesigned mill-type beaters, flotation chambers, air-wash systems, double process gins and the regin principle, were investigated before a satisfactory cleaner was developed. The cleaner that was devised utilized a combination of centrifugal force, air wash, mechanical scrubbing and combing action, and gravity. This machine, known as the saw-cylinder lint cleaner, has been accepted by the ginning industry, and a majority of gin manufacturers have either developed their own designs or have made adaptations of the ginning laboratory design. In 1951 about 900 plants, with a total estimated volume of 3,600,000 bales, were equipped with lint cleaners.

The cleaner has proved to be feasible from engineering, technological, and economic standpoints. Laboratory and field tests showed that grade improvements averaging from one-third to two-thirds of a grade may be expected from the cleaner with no adverse effect on the spinning quality of the cotton. This grade improvement has been sufficient to warrant an average additional investment of about \$20,000 and the cost of 5 to 10 additional horsepower per unit required for the operation of the cleaners. Monetary gains associated with lint cleaning averaged \$8.35 a bale in 1947, \$4.36 in 1948, and \$2.37 in 1949 on cottons of Low Middling and below in grade. The cleaner is relatively simple in design, maintenance, and operation and requires only nominal attention during operation. The amount of waste removed by the cleaners ranged from 7.1 pounds a bale for cottons of Middling and better in grade to 13 pounds for grades of Low Middling and below. The waste removed from a bale of lint by the cleaner contains about 2 pounds of short, irregular fibers regardless of the grade of cotton being cleaned.

Cost studies made on lint-cleaner-equipped gins in the Yazoo-Mississippi Delta in 1949 showed that monetary benefits from lint cleaning averaged \$2.50 a bale a season on hand-picked cotton and \$3.31 on machine-picked cotton. The waste removed from hand- and machine-picked cotton by the cleaners averaged 6.8 and 11.6 pounds, respectively. Gins equipped with lint cleaners received \$1.29 a bale more for ginning than did gins not employing this equipment. Lint-cleaner-equipped plants had an average volume of 3,409 bales as compared with 2,950 bales for gins not offering this service.

Tight seed-roll operation of lint-cleaner-equipped gins reduces the effectiveness of the gin stands and lint cleaners. A fast rate of feeding and a tight seed roll nullifies completely the effectiveness of the lint cleaners from a grade standpoint and causes fiber damage that is apparent when the lint is spun. Tight-seed-roll operation is associated with increased nep count and reductions in yarn strength and appearance grade.

Good maintenance is as essential for the proper operation of lint cleaners as of any other machine. The manufacturer's recommendations must be followed closely in adjusting and regulating the cleaners. The proper air balance in the cleaner condenser is essential in some models to obtain an effective cleaning action and to avoid excessive lint losses. Lint flues should be kept smooth, and saws, grid bars, and doffing mechanism should be kept in good repair and proper adjustment. Lint-cleaner saws should be checked once each day and foreign matter which has become impaled on the saw teeth removed. Broken glass in inspection doors should be replaced immediately to prevent disturbance of the proper air movement and balance in the machine.

Potential volume and the trend in harvesting practices are the two main items that should be considered in planning new gin plants or modernizing existing plants. Other factors to be considered include the selection of machines to meet specific needs and the selection and training of personnel. Improved or better-equipped plants enjoy an increased volume of business which, in many instances, makes improved ginning services feasible. Field studies have shown the "break-even" point to be generally from 2,500 to 3,000 bales for very elaborately equipped gins; from 1,500 to 2,000 bales for moderately equipped plants; and from 800 to 1,000 bales for gins containing a minimum amount of machinery. Efficient management may mean the difference between profit and loss and is reflected in properly ginned cotton and satisfied customers.

The grade differences between comparable hand- and machine-picked cotton have been reduced from a range of from two to three grades to about one grade, over a period of a few years. Farmers in the heavy cotton-producing areas should increase the use of mechanical harvesting methods only as long as such an undertaking proves to be profitable. By using better and more efficient cleaners as they are developed and by cooperating with specialists in many fields—including cotton breeding, defoliation, weed control, mechanical production and harvesting and ginning—cotton farmers will be able to produce better lint more economically.

The trend toward larger, better-equipped plants continues as rising machinery costs make large volume operation necessary to insure a profit. These large plants, located on all-weather roads to accommodate trucks and multibale trailers, are drawing customers from the less conveniently located gins. With larger volumes, such plants are in a position to render better service to the customer than is economically possible with small ginning volumes.

In the drying or conditioning, extracting, and packaging processes better control is necessary to regulate the various steps in ginning and thus to provide greater cotton-processing efficiency and a better end product.